

A Report on Barriers to Reducing the Use of Asthma-Related Chemicals

**Massachusetts Office of Technical Assistance and Technology
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Executive Summary

Asthma is a chronic disease of the lungs that results in the constriction, hypersensitivity and inflammation of the airways, making it difficult to breathe. It can be caused or exacerbated by exposure to certain chemicals. The Massachusetts Department of Public Health estimates that 10.4 percent of adults in Massachusetts currently have asthma with four in ten of those adults reporting that their asthma was caused by or made worse because of workplace exposure. Several hundred chemicals have been identified as causing or exacerbating work-related asthma, 68 of which are reportable under the TURA program.¹ Reducing the use of such chemicals is a strategy for public health that is increasingly important as asthma rates climb and cost effective strategies are sought to address this disturbing trend.

The Toxics Use Reduction Act (TURA) was established to foster the increased implementation of practices that use chemicals more efficiently, and the adoption of safer alternatives to chemicals that pose concerns. Companies under TURA are required to report on their use of chemicals, and are required to examine ways of reducing use. These companies have reported significant reductions in the use of chemicals that have been associated with the onset or exacerbation of asthma (“asthma-related chemicals”).² While further progress is possible, the TURA data demonstrates that reductions are feasible.

However, examination of the literature and interviews with regulatory officials, industry representatives, trade associations, and other relevant parties indicates that outside of the TURA universe of facilities, there is comparatively little movement to implement use reduction as a priority strategy in the effort to reduce asthma incidence. This report uses the example of three chemicals to contrast these two contexts: one in which we know a great deal about a chemical’s use and there is an established focus on the need to reduce use, and one in which we know very little and there is comparatively much less focus on the need to reduce use.

Outside of TURA, comparatively little is known about the use of asthma-related chemicals (and associated exposures), although we know there is significant use of asthma-related chemicals not tracked by any regulatory program in the Commonwealth. We know how many pounds of the examined chemicals companies covered by TURA are using. We know that these companies are examining their options for reducing use because they are required to do so, submit certified reports that they are doing so, and receive inspections to make sure they are doing so. We know from the reports they must submit that these companies have significantly reduced use, releases, and waste. But outside of TURA we have no comparable information, and there is little comparable motivation to examine use reduction options.

¹ *Asthma-Related Chemicals in Massachusetts: an Analysis of Toxics Use Reduction Act Data*, Lowell Center for Sustainable Production, 2009.

² *Ibid*, p. 10. From 1990 to 2005 total use of all chemicals identified as asthma-related declined by 27%. Fugitive air emissions declined 82% and point source air emissions declined 71%.

Greater attention to the goal of reducing the use of chemicals affecting asthma will produce public health and environmental benefits by preventing the occurrence of disease or lessening its severity once triggered. In addition, use reduction can have economic benefits. The TUR approach has spurred process improvements in industrial operations and commercial products, because it illuminates design and production choices, in contrast with approaches that do not prompt the evaluation of these options.

Opportunities exist for reducing the onset or exacerbation of asthma through increased attention to use reduction in a large variety of settings. Increased attention to the problem and the consideration of the methods of use reduction are means of overcoming the following barriers to the goal of reducing asthma incidence:

- Insufficient awareness that certain chemicals may cause or exacerbate asthma.
- An absence of information about where the chemicals are being used in the workplace and in products.
- A lack of information concerning how chemical use may be reduced.
- Insufficient motivation to reduce use, due to:
 - Few enforceable standards for preventing asthma,
 - Low visibility of impacts due to underreporting of asthma incidence, and
 - Lack of a standard list of common asthma-related chemicals.

Greater awareness of the benefits of reducing asthma should provide motivation for greater action. Reducing the use of asthma incidence can help reduce the cost of medical care. According to the Centers for Disease Control, “medical expenses associated with asthma increased from \$48.6 billion in 2002 to \$50.1 billion in 2007.”³ For a company avoiding the use of such chemicals the benefits include avoided productivity losses, reducing the need for medical monitoring, reducing workers compensation costs, as well as avoiding the need to reassign workers that have developed sensitivities to chemical exposures.

To make significant progress in reducing the use of asthma-related chemicals, it is necessary to develop and provide more specific information concerning the available options for using safer alternatives, or using less of the chemicals that cause or exacerbate asthma.

³ <http://www.cdc.gov/VitalSigns/Asthma/index.html#LatestFindings>. The CDC also notes that “About 2 in 5 (40%) uninsured people with asthma could not afford their prescription medicines and about 1 in 9 (11%) insured people with asthma could not afford their prescription medicines.”

The report takes a close look at three specific asthma-related chemicals or chemical categories: isocyanates, formaldehyde, and chlorine. These chemicals were chosen because they are used by TURA-covered companies, and are also used in many settings that are not covered by TURA. At the time of selecting them, the literature referred to them all as chemicals that cause asthma,⁴ although some have questioned the strength of association between exposure and asthma and the mechanism of action—irritation and/or sensitization. A recent review has raised questions about adult exposures to formaldehyde and asthma, based on review of literature over a limited time period.⁵ However, this report includes formaldehyde because the U.S. Occupational Safety and Health Administration (OSHA) currently refers to formaldehyde as a sensitizing agent, and notes that it can cause “allergic reactions” and “asthma-like respiratory problems.”⁶ Other authoritative bodies, such as the Centers for Disease Control, recommend that people with asthma avoid exposures.⁷ The American Conference of Governmental Industrial Hygienists has labeled formaldehyde a sensitizer, based on its capacity to cause dermal and respiratory sensitization.⁸ The standard scientific references on occupational asthma include formaldehyde in a discussion of chemicals that can cause occupational asthma although the asthma incidence rate has not been determined and the mechanism of induction may not be known.⁹ Also, the World Health Organization states that in children, “some case control and cross sectional studies have indicated a possible association between low formaldehyde exposure and asthma or sensitization to certain allergens.”¹⁰ This report takes the perspective that in order to reduce the incidence or worsening of asthma, the use reduction approach should be applied to all “asthma-related chemicals,” those which could cause *or exacerbate* asthma, in adults and children. It is best for all to avoid chemicals that are harmful to the respiratory system, and crucial for anyone who already has asthma to avoid anything that can trigger a reaction.

⁴ Associations with asthma vary depending on which chlorine compound is examined.

⁵ The World Health Organization (WHO) *Guidelines for Indoor Air Quality, Selected Pollutants -Formaldehyde*, WHO European Centre for Environment and Health, Bonn (2010) stated “Although some studies suggest that formaldehyde plays a role in airway sensitization, an association between formaldehyde and lung effects or sensitization in children has not been convincing owing to confounding factors in the studies, including exposure to traffic-related co-pollutants.” See Appendix 3 of this report for further discussion.

⁶ OSHA FACT SHEET, *Formaldehyde, 2011*, at http://www.osha.gov/OshDoc/data/General_Facts/formaldehyde-factsheet.pdf.

⁷ <http://www.cdc.gov/nceh/drywall/docs/WhatYouShouldKnowaboutFormaldehyde.pdf>, or see *Guideline for Disinfection and Sterilization in Healthcare Facilities*, 2008, noting that it can cause “asthma-like respiratory problems”. Formaldehyde was noted as one of the substances most frequently linked to asthma in a recent report sponsored by the National Institutes of Health on substances linked to asthma that are found in building materials (*Healthy Environments*, prepared by Perkins & Will for the NIH Division of Environmental Protection, July, 2011, http://transparency.perkinswill.com/assets/whitepapers/NIH_AsthmaReport_2012.pdf).

⁸ American Conference of Governmental Industrial Hygienists (ACGIH) 2012 Threshold Limit Values for Chemical Substances and Physical Agents. The TLV for formaldehyde (C 0.3 ppm), with SEN designation for sensitization, and A2 designation for cancer has been in place since 1987

⁹ Bernstein, Chan-Yeung, Malo, Bernstein, *Asthma in the Workplace, 3rd Edition*, 2006, “Other Chemical Substances Causing Occupational Asthma, pp. 555, 560, 561.

¹⁰ WHO, op. cit., page 188.

Use of these chemicals also raises other concerns: all three are listed as Hazardous Air Pollutants under the Clean Air Act, and all three are reportable under the Toxics Release Inventory. All three have other significant toxic aspects besides being related to asthma. For example, formaldehyde is linked with nasopharyngeal cancer, and the World Health Organization notes that its recommendation of a short-term limit of 0.1 mg/m³ to protect against sensory irritation “will also prevent long-term health effects, including cancer.”¹¹ These three chemicals were selected as examples not as the result of an analysis of data showing that these chemicals are the most toxic. They were selected because they are widely used outside of TURA as well as by companies covered by TURA, so they present a clear contrast between uses concerning which we have data, and where there is motivation to reduce use; and uses concerning which data is lacking, and motivation to reduce use may also be lacking. When these chemicals are used without awareness of their hazards or how to prevent exposures, risks are higher.

There is sufficient evidence of concern to warrant examining these chemicals: isocyanates are commonly reported at the top of lists of chemicals causing asthma in occupational settings; and the MA Department of Public Health has identified cleaning products as of concern in such settings as food preparation, healthcare support, personal care, and building cleaning, and formaldehyde as a concern in many settings, including healthcare and personal care.¹² However, it is important to note that there are many other chemicals related to asthma, some that are used in very high amounts (for example, 262,932,518 pounds of styrene use were reported under TURA in 2009).

This report uses the three chemicals not in order to brand them as the worst of the class, but because they provide clear illustration that we need to know more about how asthma-related chemicals are used in the Commonwealth, and how those uses may be reduced. Where these chemicals are covered by TURA, use is reported, and those who use the chemicals know about options for use reduction, and reductions have occurred.

Recommendations

The report therefore recommends the following actions concerning all asthma-related chemicals:

- Increasing awareness of options for reducing use by companies reporting under TURA, to achieve further progress.
- Researching use of these and other asthma-related chemicals by entities not covered under TURA and options for use reduction where exposure risks are significant, on the assumption that greater understanding will lead to reductions as under TURA.
- Working with other relevant agencies, organizations, and interested parties to increase awareness of the feasibility of preventing exposures through ***the increased implementation of use reduction as a primary strategy*** for reducing the incidence and/or exacerbation of asthma.

¹¹ WHO, p. 141.

¹² *Sensor*, Occupational Disease Bulletin, MA DPH, October, 2012.

The TURA program is taking the following actions to address barriers to the reduction in use of asthma-related chemicals:

- Organizing training on reducing the risks of exposure to isocyanates in spray foam insulation and truck-bed lining, and researching options for reducing use and/or exposure in other applications, by both TURA and non-TURA entities.
- Developing and disseminating information on the appropriate use of disinfectants, to reduce the overuse of disinfectants while ensuring their effectiveness, in facility maintenance and pools management.
- Gathering information about the use of formaldehyde by small companies and its presence in consumer products, to increase awareness of alternatives and options for exposure reduction.
- Continuing to collaborate with other agencies and organizations to develop and disseminate information that focuses on the primary prevention strategy of reducing the use of asthma-related chemicals in settings where potentially significant risks are present.

Asthma-related chemicals present special concerns, because they can have a cumulative effect. It is important to try to reduce use and/or exposures wherever such reductions are feasible, even if each individual exposure does not seem a significant or immediate risk. Greater attention to the feasibility of achieving reductions in use and thus exposure in a wide variety of settings will likely help address a growing problem.

Massachusetts can do more to promote reduction in the use of asthma-related chemicals, in fulfillment of the goals articulated in the Commonwealth's *2009 Strategic Plan for Asthma in Massachusetts*.¹³ The Commonwealth can save on medical care costs, lost productivity, and reduced personal suffering by raising awareness in the workplace and among consumers concerning the benefits of reducing the use of asthma-related chemicals.

Relevant parties should collaborate to develop and provide better information concerning the importance of examining means of avoiding the use of asthma-related chemicals. If the chemical will still be used, action such as ventilation or the use of personal protective equipment to reduce exposures is critically important, but efforts to reduce use should come first.

¹³ <http://www.mass.gov/eohhs/docs/dph/com-health/asthma/state-plan.pdf>. Goal 3 of the plan is "Reduce Exposure to Environmental Factors that Cause and/or Exacerbate Asthma", and Goal 4 is to "Develop a Roadmap for Better Understanding the Causes of Asthma and the Role of Primary Prevention".

The Most Primary Form of Prevention: Use Reduction

This report is issued in fulfillment of Section 7(K) of the Massachusetts General Law, Chapter 21I, the Toxics Use Reduction Act, which requires the Office of Technical Assistance to annually update “a report for the (Administrative) Council on toxics use reduction that identifies barriers to business implementation of toxics use reduction, pollution prevention, and resource conservation.”

Asthma can be a lifelong condition of having difficulty breathing, which can result in severe physical limitations or death if not properly treated. According to the Centers for Disease Control (CDC), the number of people suffering from it is rising.¹⁴ Massachusetts has one of the highest adult asthma prevalence rates in the U.S. In 2010, the prevalence of current asthma among Massachusetts adults was 10.4 percent (nationwide prevalence is 8.5 percent), representing a 22.4 percent increase from 2000, and about six in ten reported activity limitations because of it,¹⁵ while 40 percent was either caused or made worse by their workplace environments.¹⁶ Actual disease prevalence is considered to be higher than what is documented.¹⁷

In 2009, the Lowell Center for Sustainable Production reported to the TURA Administrative Council that many companies in Massachusetts were using “asthma-related chemicals” - chemicals known to cause asthma,¹⁸ or to exacerbate asthma.¹⁹ The Lowell Center identified approximately 335 substances that are known or suspected of causing or exacerbating asthma (some are not industrial chemicals, such as molds or proteins from plants and animals): 68 asthma-related chemicals are listed under TURA, and 41 have been used by Massachusetts companies reporting under TURA at some point. The TURA data enables the identification of trends in chemical use by those regulated by TURA, but this is only a partial picture of what is happening with asthma-related chemicals in Massachusetts.

¹⁴ <http://www.cdc.gov/VitalSigns/Asthma/index.html#LatestFindings>: one in 14 people had asthma in 2001, compared with one in 12 in 2009.

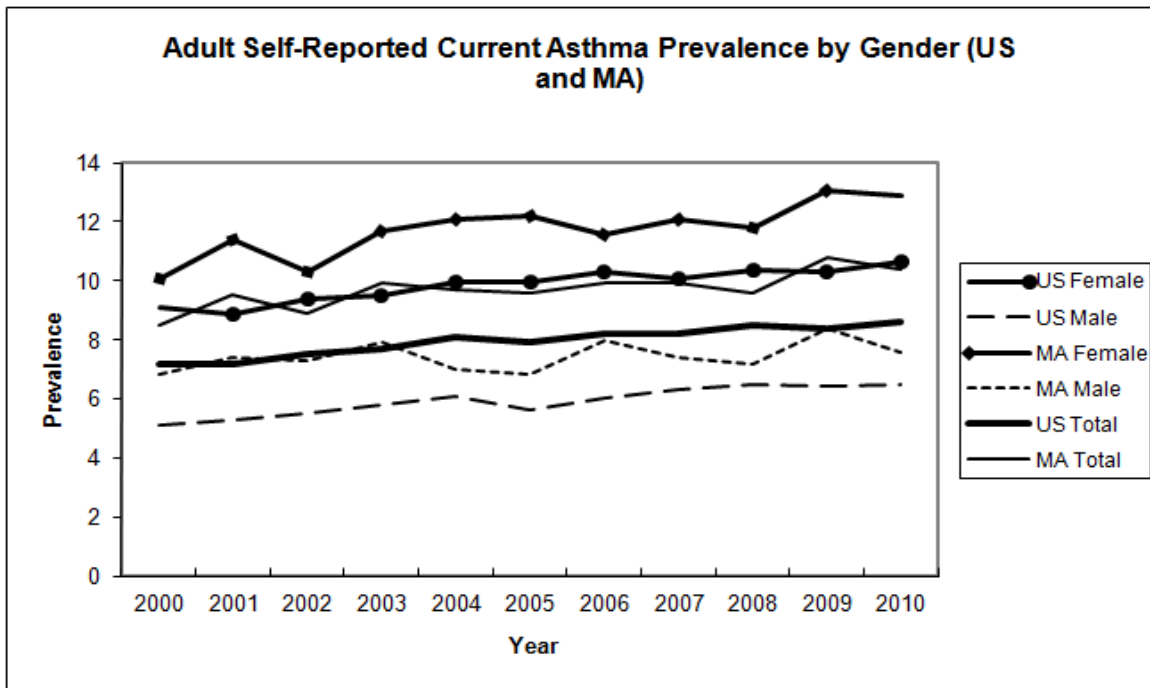
¹⁵ Massachusetts Department of Public Health, *Work-Related Asthma in Massachusetts: Population-Based Data from the 2006 & 2007 Behavioral Risk Factor Surveillance System Adult Asthma Call-Back Survey*, Oct. 2008. <http://www.mass.gov/eohhs/docs/dph/occupational-health/sensor-lung-disease-bulletins/oct08.pdf>.

¹⁶ Burden of Asthma in Massachusetts, Massachusetts DPH, Asthma Prevention and Control Program, April, 2009, http://astharegionalcouncil.org/uploads/StateAsthma%20Programs/burden_in_mass.pdf.

¹⁷ Sensor, Occupational Lung Disease Bulletin, August, 2010, <http://www.mass.gov/eohhs/docs/dph/occupational-health/sensor-lung-disease-bulletins/august2010.pdf>, page 4: “It is well recognized that only a small proportion of WRA (work-related asthma) cases are captured by MDPH and that findings from sentinel surveillance may not be representative of the underlying population with WRA in Massachusetts.”

¹⁸ Some chemicals cause an allergic reaction, which can occur at very low levels, and some cause non-allergic irritation, also known as Reactive Airways Dysfunction Syndrome (RADS).

¹⁹ See: *Asthma-Related Chemicals in Massachusetts: an Analysis of Toxics Use Reduction Data*, Lowell Center for Sustainable Production, University of Massachusetts at Lowell, Molly Jacobs, Polly Hoppin, July 2009, MA TURI Methods and Policy Report #25.



Data Source: Behavioral Risk Factor Surveillance System (BRFSS), CDC, CY2000 – 2010, Massachusetts Department of Public Health, Asthma Prevention and Control Program.

Action to prevent or avoid exposures to asthma-related chemicals can be “primary” prevention, and is more efficient and effective than responding after a medical condition has resulted. However, broad interpretation of the term includes continuing to use an asthma-related chemical while taking action to avoid breathing it. This report focuses on the type of prevention that ought to be investigated first: determining whether the use of the asthma-related chemical can be reduced or eliminated. The mission of the TUR program is to foster the approach of addressing pollution at its source rather than managing it after it has been created. The application of the TUR approach to the use of asthma-related chemicals specifically refers to how the most primary form of prevention may be accomplished. The methods of TURA – ensuring chemicals are used efficiently, and learning about alternatives – are the first methods that should be applied to the causative factors of asthma.²⁰

Reducing the source of the problem – the use of the asthma-related chemical - would in many cases be more effective and less costly than employing after-the-fact controls, such as containment, ventilation, personal protective equipment, treatment, or recycling. These all have continuous costs and their success depends on continued maintenance. Reducing the use of a hazardous chemical also often has

²⁰ Since there is evidence that dermal sensitizers can cause system reactions include respiratory problems, it is important to encompass reducing the use of dermal sensitizers that have this effect.

many other benefits, such as reducing the risk of spills and contamination, emissions to air, discharges to water, hazardous waste, and related compliance costs and liability risks. The practice of examining options for using more benign alternatives also often reveals ways to improve operations or the product itself.

Without detracting from the importance of approaches that focus more on response than on prevention of the causes of exposures, it is important to highlight the value of placing use reduction first. If the use of the chemical can be avoided, the need for control methods such as ventilation, respirators, gloves, etc., may also be avoided. Focusing first on leaving a process as it is and relying on controls to prevent exposures can cause more cost-effective opportunities to be overlooked. Once the investments have been made in control methods, there may be sunk costs that can no longer be avoided. Maintaining the effectiveness of controls requires vigilant upkeep of equipment and its application.

Once someone has been sensitized to exposures, subsequent asthma attacks can be triggered at lower and lower levels, increasing the difficulty of relying on secondary prevention to the point that removal of the worker (or chemical) from the work area may be necessary.

Many recent reports on asthma have called for more focus on primary prevention. A consensus statement by the American College of Chest Physicians (ACCP) noted that work-related asthma (WRA) and “the associated significant disability from this are potentially preventable in many cases with workplace measures and early intervention to reduce or eliminate the inciting agent....better prevention efforts are needed.”²¹ A 2008 review of relevant programs by public health professionals, led by California’s Department of Public Health, concluded that “primary prevention of occupational asthma through government-based identification and evaluation of asthma-causing agents has lagged behind primary prevention efforts for other chronic diseases.”²² It recommended the U.S. “research, identify, and ensure the efficacy and cost-effectiveness of safer alternatives” and also conduct targeted education and outreach on safer alternatives.²³

The Immediate Barriers to Reducing the Use of Asthma-Related Chemicals

There are likely many barriers to use reduction, such as cost, accessibility, technical feasibility, or whether an option is reliable and will produce a quality product. But there are more immediate

²¹ “Diagnosis and Management of Work-Related Asthma”, Am. College of Chest Physicians Consensus Statement, *CHEST* Sep. 2008, vol. 134, no. 3 suppl 1S-41S, http://chestjournal.chestpubs.org/content/134/3_suppl/1S.full.

²² Quint, J, et al., “Primary Prevention of Occupational Asthma: Identifying and Controlling Exposures to Asthma-Causing Agents”, *American Journal of Industrial Medicine*, 51:477-491(2008).

²³ Quint, op. cit., p. 490.

barriers: *the issue has not been widely treated as a priority, and information to begin to evaluate these barriers is lacking, such as exactly where asthma-related chemicals are being used.*

It is important to note that chemical exposures do not only occur in occupational settings, and that data concerning occupational exposures only tell part of the story. For example, recent concerns about formaldehyde in hair straighteners focused on hairdressers, but their clients are also exposed. Students are exposed when chemicals are used in schools. Office workers are exposed when chemicals are used in office buildings.

Motivational Barriers

The American Lung Association suggested in *A National Asthma Public Policy Agenda* that although workplace exposures could account for as much as 29 percent of adult asthma cases, regulations do not “adequately address the impact of these substances.”²⁴ Enforceable OSHA Permissible Exposure Limits “do not exist for most workplace asthmagens,” and that “Even when they do, the American Thoracic Society warned that *meeting the standards does not provide sufficient protection from workplace asthmagens. Even exposures at or below regulated levels can cause exacerbations in workers who already have asthma, allergies or other risk factors* (emphasis added).” The proposal comments that “it is generally accepted that the prevalence of work-related asthma is under-reported.”²⁵

If enforceable standards are lacking, and asthma is underreported, it is understandable that there may be a corresponding lack of motivation to investigate the feasibility of reducing the use of asthma-related chemicals. There are many other enforceable standards that require attention. The lack of a strong focus on asthma-related chemicals may be causing companies, consumers, and others to place too low a priority on the investigation of either primary or secondary prevention. Underreporting of asthma can lead to the failure to see that a problem exists. Education, calls for increased attention, and other actions are needed to help overcome the lack of motivation to pursue use reduction options.

Information Barriers

There is no regulatory list of asthma-related chemicals, such as there is for hazardous wastes, or drinking water contaminants, or carcinogens.²⁶ In addition, a 2005 U.S. Department of Health and

²⁴ <http://www.lungusa.org/lung-disease/asthma/advocacy/reports/National-Asthma-Public-Policy-Agenda-January-2009.pdf>, pp. 42-43.

²⁵ *A National Asthma Public Policy Agenda*, pp. 44-46, <http://www.lungusa.org/lung-disease/asthma/advocacy/reports/National-Asthma-Public-Policy-Agenda-January-2009.pdf>.

²⁶ The 2009 report of the Lowell Center for Sustainable Production, *Asthma-Related Chemicals in Massachusetts*, constructs a “master list of substances capable of causing or exacerbating asthma” from four sources: the Institute of Medicine’s 2000 report *Clearing the Air*, the Association of Occupational and Environmental Clinics’ Exposure database, the

Human Services report found that although more than “250 asthmagens have been implicated and identified as causative agents in the development of OA (occupational asthma)...there are likely a variety of workplace asthmagens that have yet to be identified.”²⁷ A lack of complete information about which chemicals are causing or exacerbating asthma is a barrier to bringing about the reduction of the use of asthma-related chemicals. The 2008 California DPH report (See Quint, above) and the 2009 Lowell Center report both take action to fill this gap, reviewing the existing lists.

In addition to the lack of an authoritative list, other important information gaps to address include:

- Where asthma-related chemicals are being used, and information about that use.
- Whether those who choose to use asthma-related chemicals are aware of the risks they pose.
- Whether those who choose to use asthma-related chemicals are aware of alternatives.
- Understanding the connections between occupational and environmental health impacts, and whether neighbors or ecosystems are impacted by ventilation from use of asthma-related chemicals in residential neighborhoods.
- Whether secondary prevention (adequate ventilation, engineering controls, personal protection equipment, medical monitoring) is applied where use continues.
- Whether asthma-related chemicals in products are a concern.
- Whether there might be significant ancillary benefits from a use reduction approach that might influence product or ingredient choice.

Information barriers exist for the agencies that include reduction in asthma in their mission. They also exist for those who may become, or already are, afflicted with asthma. Those who have not developed asthma should know about how to prevent it from happening and how important it is to exercise proper precautions to limit or eliminate exposure to the asthma-related chemical.

Those who are experiencing asthma also have information needs. Education, to help provide both information and the motivation to use it, is needed. For example, the CDC found in 2008 that less than half of people with asthma reported being taught how to avoid triggers.

“Almost half (48%) of adults who were taught how to avoid triggers did not follow most of this advice.” <http://www.cdc.gov/VitalSigns/Asthma/#>.

Collaborative for Health and the Environment’s Toxicant Disease database, and a comprehensive review by Malo and Chan-Yeung published in Bernstein’s 2006 edition of *Asthma in the Workplace*.

²⁷ Diagnosis and Management of Work-Related Asthma, <http://www.ahrq.gov/clinic/epcsums/asthworksum.htm>.

The Available Data

Five hundred facilities, out of the thousands in Massachusetts, now report chemical use under TURA. Only those classified as industrial, who use more than a quantity threshold (for most chemicals, 10,000 or 25,000 pounds), and have more than ten employees must report. Use of asthma-related chemicals by companies using lesser quantities in a year or with fewer employees is not covered. TURA also only covers chemical use that occurs at the reporting facility: many work sites using chemicals are not included (for example, application of isocyanate-based spray foam insulation at construction sites). Companies covered under TURA must examine and report to the public concerning quantities used, released to the air and/or water, and managed as waste. The companies must conduct TUR planning, which focuses attention on the potential for use reduction, including benefits such as reduced compliance and waste management costs, production efficiency improvements, increased worker and public safety, and greener products. *Because of the external and internal scrutiny that TURA requires, and the knowledge of alternatives that it fosters, TURA provides the motivation to make a priority of use efficiency and alternatives assessment.*

Using the TURA data, it is possible to roughly assess a company's performance – to see trends in the efficiency of its chemical use: whether it is using more or less of a chemical to make the same amount of product, and whether it is having more or less waste from each pound of chemical used.

Although some increases have occurred in the use of asthma-related chemicals by the population reporting under TURA (such as the use of ammonia), significant reduction in use and releases is occurring in a variety of industrial settings where companies are covered by TURA. From 1990 to 2005:

- **Total fugitive emissions declined 82 percent** (primary contributors: ammonia, sulfuric acid, acetic acid, styrene monomer, and nitrogen dioxide).
- **Point source emissions declined 71 percent** (primary contributors: sulfuric acid, ammonia, formaldehyde, acetic acid, and styrene monomer).

However, a great deal of the use of asthma-related chemicals is not covered by TURA. In addition to work sites not covered by TURA, consumer exposures from products are another recognized area of concern where TURA provides no information. There are many locations of potential exposure, where the lack of information about and by those at risk is a barrier to effectively addressing them.

Interagency Consultations: Selecting a Focus

After a presentation to the TURA Administrative Council in 2010 by the Lowell Center, discussions took place between staff of the Massachusetts Department of Public Health, OTA, TURI, and the state's OSHA Consultation program. Information about asthma-related chemicals was shared, and based on the judgment of participants, three chemicals were selected to examine more closely: isocyanates, formaldehyde, and chlorine. The chemicals were not chosen because of a conclusion that these three chemicals pose the greatest risks, but because of agreement that all three have relatively high prevalence of use, that the risks associated with use could be mitigated through greater attention, and they presented interesting comparisons relevant to the issue of whether options for reducing use are examined.

OTA then performed an analysis of individual company performance for all companies in TURA using those chemicals since the year 2000. These analyses showed general trends towards reducing use, byproduct, and releases of these chemicals. The results of these analyses are presented below in the sections devoted to each of the three chemicals.

OTA also distributed a survey to 188 companies that had reported using asthma-related chemicals at one time under TURA (from 2000-2009). The survey solicited information about how reductions had been achieved and where they have been achieved. TUR Planner credits were offered for responses, and the more informative the response, the more credits could be provided. Only one company responded, earning one TURP credit.²⁸ A response rate of less than one percent is rare for any outreach that OTA performs, and in this case there was an incentive – TUR Planner credits – for responding. (The survey is attached to this report as Appendix One).

Isocyanates, Formaldehyde, and Chlorine

The following sections examine three chemicals (or chemical categories) that have been identified as asthma-related, focusing on what we know about use, and opportunities to reduce use and/or prevent exposures. Two points of clarification are necessary: asthma causation or exacerbation is not the only potential concern raised by the use of these and other chemicals; and the identification of risks in chemical use is not intended to negate their potential value when used appropriately. Isocyanates that have reacted and cured do not pose a threat of respiratory harm in the absence of fire and provide effective insulation, reducing energy consumption, as well as many other useful applications;

²⁸ The company reported investigation of using trivalent chromium as an alternative to hexavalent, noting that they had converted to trivalent chrome in the past but had to change back "because of customer rejection of the color difference". However, newer processes are "beginning to approach the hex chrome color." The company has reduced byproduct in a variety of ways and continues to work on it, asking some of its customers to consider changes in product design to improve the draining of chemicals in process (and reduce dragout from the process, thus leading to reduced byproduct generation).

formaldehyde and chlorine may be used in many settings without significant risks and are regarded as key to the production of a wide variety of products; and maintenance of public health is currently dependent on chlorination of drinking and waste water. The approach of TURA is not to prohibit the use of chemicals that pose risks, but to focus on using the smallest amounts necessary, as carefully as possible, and to ensure the consideration of safer options.

For each of the three chemicals, we examined TURA information, and whatever other sources we could find concerning use of the chemicals.

The Value Of Being Covered By TURA

All three of the selected chemicals are reportable under TURA. If advances occur concerning safer alternatives, TURA provides a mechanism for increasing the chances that the information will be considered. The companies that use the chemicals are known and can be provided with information, the TUR Planners who certify plans take continuing education courses, and when the companies must do TUR plans, they are motivated to seek out information about substitutes. Even if a company's business plan is strongly focused on continuing to use the chemical, the company can still focus on areas where use may be made more efficient, and pursue research to identify technically feasible, cost-effective alternatives.

Method of TURA Analysis Used

TURA data provide indications on where use reduction opportunities may exist. These indicators are:

- If a company has increased use, and changes in production do not account for it, (the data shows that the company is using more pounds of toxics to make the same amount of product).
- If a company has increased byproduct relative to use, (it is generating more waste per pound of input).
- Releases have increased (fugitive releases are primarily a risk to workers, point source releases may be a risk to the community and the environment).

We examined the reports of isocyanate, formaldehyde and chlorine users to see if any "red flags" appeared - visible indications that companies continuing to use the chemicals may have decreased efficiency, appearing as negative changes in "use efficiency" or releases. These may represent meaningful opportunities for targeting offers of assistance, or other interventions. Though such performance measurement may be useful in targeting scarce agency resources, it is not definitive. Negative changes could be due to diligence on the part of the company, but they could also be explainable or unavoidable.

In general, the companies reporting chemical use under TURA presented no red flags. With few exceptions, the overall trend is positive: significant reductions in use, releases, and waste byproduct. This finding is consistent with the annual reports for all chemical use under TURA, and confirms the central strategy of the law, that bringing about greater awareness of use and use reduction opportunities would spur voluntary reductions. TURA does not require anyone to reduce use of any chemical: reductions have been achieved by directing attention to the importance and feasibility of reducing use.

Isocyanates

Isocyanates are “derivatives of isocyanic acid, $\text{HN}=\text{C}=\text{O}$, in which alkyl or aryl groups, as well as a host of other substrates, are directly linked to the NCO moiety via the nitrogen atom”.²⁹ In industry they are reacted with compounds containing alcohols, carboxylic acids, and amines to produce a variety of products, such as polyurethanes, used to make foam and coatings³⁰. OSHA notes that the main effects of exposure are “occupational asthma and other lung problems, as well as irritation of the eyes, nose, throat, and skin,” but that isocyanates also “include compounds classified as potential human carcinogens and known to cause cancer in animals.”³¹ The most-used isocyanates are toluene diisocyanate (TDI) and methylene bisphenyl diisocyanate (MDI). TDI is used mainly to make soft, flexible foams, and MDI is used mainly to make hard, rigid foams. Isocyanates are also used in the manufacture of coatings, plastics, laminated fabrics, and adhesives.

OSHA has set permissible exposure limits for both of these compounds.³² The American Conference of Governmental Industrial Hygienists (ACGIH) has set (nonenforceable) Threshold Limit Values for the aliphatic diisocyanates hexamethylene diisocyanate (HDI), isophorone diisocyanate (IPDI) and hydrogenated MDI (HMDI), and the National Institute for Occupational Safety and Health (NIOSH) recommends a general standard that isocyanate exposures should not exceed the vapor equivalent of an 8-hour time-weighted average (TWA) exposure of 5 ppb, or a short-term or ceiling exposure of 20 ppb, to calculate exposure limits for diisocyanates that do not have specific recommended limits.³³

In discussions of workplace exposures this class of chemicals is commonly cited. For example, the 2005 report Department of Health and Human Services report on *Diagnosis and Management of Work-Related Asthma* found it one of the most common exposures in a wide variety of settings, and that it is

²⁹ Kirk-Othmer *Encyclopedia of Chemical Technology*, 4th edition, 1994, Vol. 14, p. 902. All chemicals reported under TURA thus far have been diisocyanates, which have two moieties (a part or functional group of a molecule).

³⁰ Kirk-Othmer *Concise Encyclopedia of Chemical Technology*, 5th Edition, 2007, p. 1133-4.

³¹ <http://www.osha.gov/SLTC/isocyanates/index.html>.

³² The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for TDI is 0.02 part per million parts of air (0.02 ppm), or 0.14 milligram per cubic meter of air (0.14 mg/m³) as a ceiling limit [29 CFR* 1910.1000], <http://www.cdc.gov/niosh/docs/96-111/>. OSHA has a PEL for methylene bisphenyl diisocyanate (MDI) monomer (20 ppb ceiling), but not for polymeric MDI. http://www.osha.gov/dts/chemicalsampling/data/CH_263650.html.

³³ For more on specific limits, see: <http://www.cdc.gov/niosh/docs/2004-116/pdfs/2004-116.pdf>.

estimated that “up to 11 percent of workers exposed to di-isocyanates will develop bronchial hyper-reactivity.”³⁴ Citing NIOSH, OSHA’s green jobs website states that isocyanates “have been determined to be the leading attributable cause of work-related asthma.”³⁵ Although exposure to the finished product, solid polyurethane foam or a plastic coating, does not present concerns of toxicity, burning or heating polyurethane products at high temperatures does produce toxic releases, and abrading produces dusts that can cause concern. According to the California Department of Health Services, “Any polyurethane material will give off isocyanates and other highly toxic substances if it is burned or welded. The isocyanates in single-component coating products such as Varathane are pre-polymerized (already chemically reacted), so that very little of the raw isocyanate remains; thus they are fairly safe even during application. Two-component coating products contain unreacted isocyanates and are usually much more hazardous to work with.”³⁶

The agencies involved in the interagency effort were all already familiar with isocyanate exposures in certain sectors. OTA, for example, performed significant outreach for several years beginning in the late 1990’s. Its “CRASH Course” guidance, which has been used and replicated widely, includes both protective and preventive information concerning exposures from spray painting. TURI has funded the Boston Public Health Commission to perform outreach more recently, and its work is currently ongoing. The Occupational Safety program of the Division of Labor Standards has included information in its public bulletins on preventing exposures to isocyanates, advising that “all two-part epoxies and sealants should be suspected of containing isocyanates”, and if so, ventilation and proper respiratory protection are advised, along with clearing the building, sealing ducts to prevent migration of vapors, and planning for generous curing and drying times before allowing reoccupation.³⁷

Below, we look first at the information about isocyanate use by one sector of the population that reports under TURA, followed by other uses not covered by TURA.

Isocyanate Use By Large Quantity Toxics Users Reporting Under TURA

We examined each company reporting isocyanate use from 2000 – 2009, using publicly available TURA information obtained from MassDEP.

- In 2000, 37 companies reported using above-threshold amounts.
- By 2009, 17 companies - 46 percent of the reporting population - had dropped use below threshold and were no longer reporting.

³⁴ Evidence Report/Technology Assessment Number 129: see pp. 5 and 25;
<http://www.ahrq.gov/downloads/pub/evidence/pdf/asthmawork/asthwork.pdf>.

³⁵ https://www.osha.gov/dep/greenjobs/spf_chemical.html.

³⁶ <http://www.cdph.ca.gov/programs/hesis/Documents/iso.pdf>

³⁷ See, for example, <http://www.mass.gov/lwd/docs/dos/mwshp/hib388.pdf>.

- Total use of isocyanates dropped from 14,432,632 pounds in 2000 to 11,860,966 pounds in 2009, an 18 percent reduction (2,571,666 pounds).

The overall numbers show that there have been significant reductions in chemical use, but that substantial use of isocyanates continues.

Input (Use)

Of the 20 companies that were reporting both in 2000 and 2009, 10 decreased use over the period, and 10 increased use. All companies using isocyanates processed the chemical, and incorporated it into their product.

The company with the most use of isocyanates in 2009, (5,323,121 pounds) accounted for 45 percent of total use. The company reduced its use from 6,783,314 pounds in 2000 to 5,323,121 in 2009. However, the company's use did go up during some of the intervening years. Just looking at totals at the beginning and end of a time period does not provide a complete picture: it is necessary to consider the company's reported production ratios, a relative measure of the amount of product made from year to year, in which the chemical is incorporated. This will indicate if the chemical use is going up or down because production is going up or down.

The increases and decreases for the largest user tracked changes in production very closely: the changes in production account for the changes in use. The same story was found for the other largest users. Two companies experienced spikes in which for one or two years use increased without increases in production. However, in the last two years of the period both of these companies returned to previous performance levels.

The examination of chemical input efficiency did not indicate any current red flags. This does not mean that there are no opportunities for improvement, rather offers of assistance should still be made, to help with finding opportunities to change processes, and research on advances in substitutions or processing should remain a priority. However, chemical input efficiency is not the only measure of use efficiency.

Byproducts

If a company must use a chemical to make its product, it is still possible to reduce toxics use by ensuring that the maximum amount goes into the product and the least amount is wasted.

The trends for all the companies that had increases in use from 2000 to 2009 were positive – by the end of the time period each one had improved their byproduct/use ratio.

Releases

Although no release to the environment of an asthma-related chemical is good, the releases of the examined companies were extremely small in comparison to other large quantity toxics users in the Commonwealth. No company exceeded 300 pounds in any year. Four of the companies that had increases did not report any releases in all reporting years. By comparison, in 2009, the population of 500 large quantity toxics users reported 5 million pounds of releases, an average of 10,000 pounds each. This may simply reflect the different roles chemicals can play in production, and that isocyanates in Massachusetts are processed into product, rather than otherwise used.

However small the releases, they show a downward trend. Fugitive releases from the companies that increased use were reduced by 44 percent over the nine-year period, and point releases were reduced by 93 percent. One company experienced a doubling of releases in 2007 and 2008, but had reduced below its starting level by 2009. TURA also measures transfers, which includes shipments for waste treatment or recovery. These rose by about 37,800 from 2000 to 2009. When reductions in releases are not achieved by use reduction or efficiency, they are achieved through improved controls, and an increase in transfers (for waste or wastewater treatment) is often complementary to reductions in releases.

Appendix Two contains a summary of current TURA data from all companies reporting isocyanates in 2009.

Isocyanate Use Not Tracked By TURA

In 2008 U.S. consumption of isocyanates was 2,175,360,000 pounds.³⁸ If you assume that consumption in Massachusetts is proportional to its percentage of the national economy (two percent), then use in the state would be on the order of 44 million pounds.³⁹ The total reported under TURA for 2008 was 14.6 million pounds, representing about only 0.6% of national consumption. These numbers indicate the possibility that the information we have about use of isocyanates in the state may be only one-third of the use that occurs.

A web-search turns up more than a dozen companies providing spray foam insulation services in Massachusetts, each applying it presumably in many locations. Also, there are companies that sell

³⁸ *Chemical Economics Handbook*, SRI International, "Diisocyanates and Polyisocyanates, Marketing Research Report, 2009." SRI makes no warranties as to the accuracy, completeness or correctness of the information.

³⁹ MA had a GDP of \$230 billion and the US of more than 10 trillion. *GDP by State*, U.S. Bureau of Economic Analysis, <http://www.bea.gov/regional/gdpmap/GDPMap.aspx>, accessed Feb. 3, 2012.

systems for do-it-yourselfers or small contractors who do not have websites.⁴⁰ At a 2011 meeting considering sustainability criteria for thermal insulation, representatives of companies selling isocyanates for use in spray foam told panel members that at least 40 percent of their product was sold to users that may not have been trained in proper application.⁴¹ Isocyanates are used not just at construction sites and home energy retrofits, but by:

- Autobody shops
- Companies using foams
- Companies using adhesives
- Companies using coatings
- Companies making plastics
- Companies laminating fabrics
- Companies burning or finishing articles containing these items (burning can cause toxic emissions and finishing operations can generate dusts).
- Consumers using spray cans and glues, sometimes in unventilated spaces⁴²

To target where potentially hazardous processing may be taking place, more specific information could not be found. The MA Department of Labor Standards' Onsite Consultation Program (Consultation program) responds to requests for assistance with occupational safety, but does not have information about the size of the populations noted above. The regional office of OSHA does not have this information at this time.⁴³ Thresholds in Tier 2 reports, and the quality of Tier 2 reporting data, seriously limit the value of this data for describing the population that uses isocyanates.⁴⁴ Air emission reports are similarly limited.

The Consultation program has visited over a dozen spray-on bedliner shops, and found that without exception, employees applying the isocyanate-based coatings used supplied-air respiratory protection, tyvek suits, and protective gloves when spraying. However, glove use was inconsistent among employees while they were setting up their equipment, raising the potential of dermal exposure to

⁴⁰ <http://www.sprayfoam.com/cdps/minorcat.cfm?cid=7&ckid=125>.

⁴¹ Standards Technical Panel meeting, Underwriters Laboratory Environment, June 28-29, 2011, Northbrook, IL. See http://www.epa.gov/dfe/pubs/projects/spf/spray_polyurethane_foam.html for guidance and free training resources recommended by the U.S. Environmental Protection Agency.

⁴² A special focus on alerting consumers may be advisable, concerning the possibility that skin exposure can cause sensitization, "with subsequent inhalation challenge resulting in asthma-like responses." Bello, et al., "Skin Exposure to Isocyanates: Reasons for Concern", *Environ Health Perspect.* 2007 March; 115(3): 328-335. See also Redlich, "Skin Exposure and Asthma Is There a Connection?" *Proceedings of the American Thoracic Society*, May 1, 2010 vol. 7 no. 2 134-137: "recent studies suggest that the skin may also be an important route of exposure and site of sensitization that contributes to asthma development."

⁴³ Personal Communication with staff at OSHA, Region One.

⁴⁴ Personal Communication with staff at EPA, Region One New England.

isocyanate monomer. OSHA exposure limits apply to aerosol-forming activities such as spraying, or mixing that cause significant inhalation hazards.

Dermal contact is also an issue any time isocyanates are used, because it may induce systemic sensitization, with subsequent inhalation challenge.

In addition, approximately half of the employees of spray foam insulation contractors visited by the Consultation Program were spraying foam without using supplied air respirators recommended by the manufacturers, but air-purifying respirators instead. All of the employees who were trimming the cured foam, who were often in the same room and fairly close to the applicators, used air purifying respirators, which are not adequate protection during application. Training on the proper use of respiratory protection was also inconsistent, ranging from fairly thorough training to none. Tyvek suits were worn by employees who sprayed the foam product, but were generally not worn by employees trimming the cured foam. This can cause dermal sensitization if uncured monomer is present.⁴⁵

Recommendations

Concerning companies under TURA, OTA should continue to gather information from companies that have achieved reductions, to share successful practices more widely. The TURA program should continue to monitor information about potential substitutions. Even a company that has high use efficiency and low releases may benefit from information about available safer chemicals. Soy-based alternatives are often suggested, but EPA's Action Plans for TDI and MDI mention that "more research is needed to determine if soy-based adhesives would be an adequate substitute for polyurethane adhesives", and the soy-based content of insulating foam is yet minor.

Concerning uses not covered by TURA, the program and the TURA Council agencies can:

- Explore means of increasing the chances that spray-foam insulation application will be conducted responsibly, by properly trained individuals. Spray-foam insulation involving two-component reaction is increasing due to the rising interest in energy efficiency and weatherizing homes. The American Chemistry Council's Center for the Polyurethanes Industry and the Spray Polyurethane Foam Alliance have created, with participation from relevant federal agencies such as OSHA and the EPA, a free Spray Polyurethane Foam Chemical Health and Safety Training. The program has begun discussions with the Center to bring this training to Massachusetts. The program can take action to educate the public about the need to use contractors that have taken the training.⁴⁶ (The U.S. Environmental Protection Agency's Design

⁴⁵ Personal communication, MA Division of Labor Standards, OSHA Consultation program.

⁴⁶ At <http://spraypolyurethane.org/SPF-Chemical-Health-and-Safety-Training>. OTA and the ACC are currently in discussion concerning holding these trainings in Massachusetts.

for the Environment program, a partner in this effort, found that clear information on the hazards and access to the information “vary widely across the industry.”⁴⁷ There are no current requirements to take this training, and a lack of awareness on the part of both contractors and customers may be a barrier to proper practice. The program has also begun discussions with the regional OSHA office concerning such training.

- Investigate whether autobody shops have been able to switch to nonisocyanate coatings and where targeted outreach might be needed. Preliminary research indicates that feasible substitutes have been found for pigmented paints but not for the clear top-coating. What is the state of professional and customer acceptance of the alternatives? Can it be increased? Investigate the extent to which autobody shops have installed supplied-air respirators for applicators, and if spraying is occurring in compliant booths. Do shops need assistance to specify and purchase the appropriate equipment? Develop outreach on safer application practices for this industry and for truck-bed lining.
- Investigate other industries where isocyanates are used, (adhesives, coatings, foam, etc.) and the availability of acceptable alternatives. Focus on recommended occupational safety measures, particularly on small businesses not likely to be covered by TURA or other regulatory enforcement. Investigate whether small businesses need financial assistance or training to implement reductions in the use of asthma-related chemicals, and whether the state can help by promoting customer understanding. Link efforts to address safe use with the examination of alternatives.
- Develop information for do-it-yourself applications, stressing the need for ventilation, avoidance of skin contact, the care required for proper curing, the risks from burning or abrading, and the availability of alternatives.

Formaldehyde

Formaldehyde, $H_2C=O$, begins a series of aliphatic aldehydes, and because “of its relatively low cost, high purity, and variety of chemical reactions,” is one of the world’s most important industrial chemicals. (Formaldehyde is also found as a natural component in foods and is a normal body metabolite.)⁴⁸ In 2004, U.S. production was 9,534,992,839 pounds and consumption was 9,507,960,000 pounds. Formaldehyde is generally produced for local consumption, with world trade accounting for only two percent of production in 2003, as it is easy to make but costly to transport. Its primary use is to make urea-, phenol- and melamine-formaldehyde resins. Particle-board and plywood

⁴⁷ Mary Cushmac, February 9, 2011 presentation to Spray Polyurethane Foam Alliance, slide 6, http://www.epa.gov/dfe/pubs/projects/spf/epa_niosh_osh_a_spfa_conference_presentation_february_2011.pdf

⁴⁸ Kirk-Othmer Concise Dictionary.

using urea- and phenol -formaldehyde resins account for more than one-third of demand.⁴⁹ Total usage in Massachusetts by facilities reporting under TURA was 2,358,446 in 2009. The majority of applications are in wood and construction-related industries as urea-formaldehyde, phenol-formaldehyde and melamine-formaldehyde glues, resins and stiffeners; followed by uses as a chemical intermediate (e.g. pentaerythritol, hexamethylenetetramine, butanediol) to manufacture another chemical of commerce. Some is used in specialty thermoplastic resins, in the textile/apparel industry as a whitener/finisher/stiffener for items of clothing and an additive for wrinkle-resistance and crispness of appearance, and for preservative additives in soaps, lotions, shampoo, etc.

OSHA PELs exist to control worker exposures (Action level, 0.5 ppm; Time-Weighted Average, 0.75; Short-term Exposure Limit, 2). Formaldehyde is also classed as a probable human carcinogen by the International Agency for Research on Cancer and as a suspected human carcinogen by the American Conference of Governmental Industrial Hygienists.

Formaldehyde was selected as a focus because it is contained in and released from many products, sometimes in indoor air; it is a newly-listed “Higher Hazard Substance” under TURA, requiring the program to scrutinize uses by smaller quantity users; it was recently confirmed by the National Academy of Sciences review panel as carcinogenic; it has appeared as a concern in hair smoothing products gaining in popularity,⁵⁰ and many exposures are likely preventable.⁵¹

Use Under TURA

A review of the TURA data (from 2000 – 2009), shows large quantity toxics users required to report under TURA reduced:

- Use by 3,308,570 lbs, a 56 percent reduction.
- Byproduct by 140,417 lbs, a 70 percent reduction.
- Releases by 82,880 lbs, an 86 percent reduction.
- Transfers by 64 percent.

Of the 2,358,446 pounds used in 2009, 13,088 pounds were released. Of nineteen companies reporting during the nine years examined, only six were still reporting in 2009. Half of these companies had reduced use since their first year of reporting, and half had increased. Most recently,

⁴⁹ 2004 *Chemical Economics Handbook*.

⁵⁰ A 2011-12 Bulletin from the Massachusetts Department of Public Health notes that a 2010 Oregon OSHA program tested 100 products from 50 salons and found significant levels of formaldehyde in products labeled “formaldehyde-free”, and that a NIOSH sampling in Ohio found levels above the ceiling limit of 0.1ppm in 6 of 7 salons. Growth in this area is projected at 20% by 2018.

⁵¹ OTA received a communication from the American Chemistry Council cautioning “against any effort to finalize the recommendations regarding formaldehyde”, contending that “it is inappropriate to suggest a relationship between formaldehyde and asthma.” To understand OTA’s decision to go forward with the report, see the Executive Summary and Appendix 3.

only one had improved its input use efficiency – the other five had used more formaldehyde to make the same amount of product in 2009 than they had used in 2008.

Byproduct/use ratios averaged about half a percent for the companies processing formaldehyde, but were far larger for those companies otherwise using the chemical. For example, all formaldehyde used by one company was reported as byproduct, and this has remained constant over the years. Four of the six companies improved their byproduct/use ratio from their first year of reporting, one had a very slight negative change.

Appendix Two contains a summary of TURA information from companies reporting formaldehyde in 2009.

Uses Not Tracked By TURA

A Variety of Workplaces

A 1990 OSHA Enforcement Directive⁵² cites many uses of formaldehyde. The major users are the manufacturers of compressed wood products, for resins that are used as glues in the production of particle board, plywood, and fiberboard, which are then used in the construction, furniture, and mobile home manufacturing industries. Other areas to examine include:

- Plastics (molding compounds containing melamine, phenolic, or acetyl resins when subjected to heat and/or pressure)⁵³
- Foundries (molding operations)
- Wrinkle-free and durable press textiles, waterproofed textiles
- Alkyd and acrylic coatings
- Clear coating for wood furniture
- Primer coats for automobiles
- Baked enamels for appliances
- Can coatings
- Chemical-, exposure- or corrosion-resistant coatings
- Paper products requiring wet- strength or other finished quality

⁵² OSHA Instruction CPL 02-02-052, 11/20/90, Office of Health Compliance Assistance, http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=DIRECTIVES&p_id=1566.

⁵³ “the final product, however, contains little free formaldehyde and has little potential for depolymerization, so that potential exposure to formaldehyde from use of the plastic product is minimal.”

- Embalming, anatomy, histology, pathology laboratories
- Rubber production
- Manufacturing of some detergents, fertilizers, explosives, abrasive products, pharmaceuticals, and as a bactericide in cosmetic products, shampoos, and hair sprays
- Cleaning dialysis equipment.

Exposures can occur in a wide range of workplaces, in transfer operations, reactor or vessel cleaning, and before curing, and particularly where heat and/or pressure is applied in the processing of products made from or including formaldehyde-bearing resins, such as pressing wood products, extrusion or injection molding of plastics, heat-setting of pleats on apparel, and mold casting at foundries. But exposures also occur as a result of offgassing from finished products, or through what EPA has termed "pseudoconsumptive use", the chemical break-down in warm and humid environments of formaldehyde-containing materials to produce formaldehyde gas. This can occur outside of the workplace as well.

OSHA and the Food and Drug Administration (FDA) have alerted the public to concerns about hair-smoothing products used in beauty salons: FDA released a warning letter that it sent on August 22, 2011, to the CEO of the company distributing "Brazilian Blowout Acai Professional Smoothing Solution," asserting that it was adulterated because it contains methylene glycol, which is formaldehyde in an aqueous solution, and would release formaldehyde when heated with blow dryers and/or flat irons. The warning also stated the product was misbranded because it said it was formaldehyde free.⁵⁴ OSHA noted warnings have issued from several states, that formaldehyde levels have been found in the air at multiple salons, and that several companies have failed to include correct hazard warnings on the product's label or Material Safety Data Sheet (MSDS). "Many keratin-based hair smoothing products contain formaldehyde," which may be listed as:

- Methylene glycol
- Formalin
- Methylene oxide
- Paraform
- Formic aldehyde
- Methanal
- Oxomethane
- Oxymethylene
- Cas number 50-00-0.

⁵⁴ U.S. Department of Health and Human Services, Inspections, Compliance, Enforcement and Criminal Investigations, <http://www.fda.gov/ICECI/EnforcementActions/WarningLetters/2011/ucm270809.htm>.

OSHA notes that all of these are formaldehyde, and that timonacic acid (also called thiazolidinecarboxylic acid) can release formaldehyde under conditions such as are present in hair-smoothing.⁵⁵ In 2011 OSHA issued citations to 23 salon owners and beauty schools in eight states, including Massachusetts.⁵⁶

The FDA also advises that nail hardeners can contain formaldehyde, which can cause “irritation or allergic reaction to those sensitized to this compound”, and that there is “also some evidence that certain individuals may become allergic to toluene-sulfonamide-formaldehyde resin, a common ingredient in nail preparations.”⁵⁷

A 1994 TURI report on mortuaries (noting several opportunities for reducing the use of formaldehyde, such as changes in the burial procedures, disinfection with an alcohol solution and use of personal protective equipment for funeral service employees, refrigerated storage, and use of enclosed container or closed casket), estimated that 249,920 gallons of embalming fluids containing approximately 180,163 pounds of formaldehyde were used in the state.⁵⁸

Schools and hospitals are potential sources of exposure, when formaldehyde is used in the preservation of biological specimens, or tissue samples. Employees, students, and patients are all vulnerable if vapors are released to indoor environments.

In Homes

A recent review of the epidemiological literature draws attention to associations between indoor residential chemical emissions and respiratory and allergic effects in children. The risk factors “identified most frequently included formaldehyde”.⁵⁹ EPA’s Indoor Air Quality program notes that in homes, “the most significant sources are likely to be pressed wood products”, such as:

- Particle-board in subflooring, shelving, cabinetry, furniture
- Hardwood plywood paneling in decorative wall covering, cabinets, furniture
- Medium density fiberboard in drawer fronts, cabinets, furniture tops.

⁵⁵ Hazard Alert Update, Hair Smoothing Products That Could Release Formaldehyde, http://www.osha.gov/SLTC/formaldehyde/hazard_alert.html.

⁵⁶ News Release, U.S. Department of Labor, 11-1735-NAT, Dec. 8, 2011, “U.S. Department of Labor continues to cite beauty salons and manufacturers for formaldehyde exposure from hair smoothing products”.

⁵⁷ *For Consumers, Nail Products*, <http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm115861.htm>.

⁵⁸ *Formaldehyde Use Reduction in Mortuaries*, Chengchen Mao, Professor Susan Woskie, Work Environment Department, Technical report #24.

⁵⁹ Mendell, “Indoor residential chemical emissions as risk factors for respiratory and allergic effects in children: a review”, *Indoor Air*, 2007, 17: 259-277. The article notes that “A period of concern during the 1980s about irritation symptoms from formaldehyde-emitting products such as insulation and particleboard resulted in public concern, changes in product formulation, and lowered emissions of formaldehyde. Although indoor levels since then have popularly been considered sufficiently low to allay health concerns, findings reviewed here suggest otherwise.” (At 269).

EPA notes the medium density fiberboard has a higher resin-to-wood ratio and is “generally recognized as being the highest formaldehyde-emitting pressed wood product.”⁶⁰ EPA also notes that pressed wood with phenol-formaldehyde (PF) resins, used in softwood plywood and flake or oriented strand board for exterior construction “generally emit formaldehyde at considerably lower rates than those containing UF (Urea-formaldehyde) resin.” Other sources in the home from products include durable press drapes and other textiles, insulation, glues, as well as combustion sources and smoking. EPA recommends using PF instead of UF; maintaining moderate temperatures and humidity; increasing ventilation, especially after purchasing formaldehyde-containing products; and asking about the formaldehyde content of products containing pressed wood.

Limits on formaldehyde emissions from composite wood have been set by national legislation signed by President Obama in July, 2010, which directs EPA to promulgate final regulations by January 1, 2013.⁶¹ The national emission standards “mirror standards previously established by the California Air Resources Board,”⁶² and apply to hardwood plywood, medium density fiberboard, and particleboard sold, supplied, offered for sale, or manufactured in the United States.

Available Information about Use and Reducing Use

Formaldehyde is widely used in many applications. Information concerning exactly where it is used in Massachusetts and how carefully, or whether use reduction opportunities are being explored, is scarce. Concerning exposures in the home, some advisories have been issued by state and federal health and environmental authorities, focusing on secondary prevention. For example, an Illinois Department of Public Health Fact Sheet advises:

A simple and effective way to reduce formaldehyde levels in the home is to increase air flow in the affected area by opening windows and doors. This lowers the level of formaldehyde by increasing the amount of outdoor air. Usually, the levels decrease and odors are gone within a few days.

Another way to reduce exposure is to apply a barrier between formaldehyde containing surfaces and the indoor air. Products such as latex-based paints or varnish can block formaldehyde “off gasses.” The use of vinyl coverings such as wallpaper and floor covering on particle board panels also has been effective. If all other efforts fail to reduce formaldehyde to manageable levels, removing formaldehyde containing products from the home environment may be necessary.⁶³

Others focus on primary prevention. For example, the California Air Resources Board recommends:

⁶⁰ *An Introduction to Indoor Air Quality: Formaldehyde*, <http://www.epa.gov/iag/formald.html>.

⁶¹ Formaldehyde Standards for Composite Woods Act, Title VI, Toxic Substances Control Act.

⁶² *An Introduction to Indoor Air Quality*.

⁶³ <http://www.idph.state.il.us/envhealth/factsheets/formaldehyde.htm>.

Avoid buying uncoated pressed wood products made with urea-formaldehyde (UF) resin: these include many plywood and particleboard products used indoors, such as cabinets and desks. Substitute other building materials for formaldehyde-containing pressed wood products. Consider using formaldehyde-free materials such as solid wood, gypsum board, some hardboard products, stainless steel, adobe, bricks, tile, and plastic. Use formaldehyde-free insulation. Consider buying used or antique furniture; formaldehyde emissions decrease as products age. When buying pressed wood products, purchase low-emitting products:

- Choose pressed wood products made with phenol formaldehyde (PF) resin or methylene diisocyanate (MDI) resin; these products emit much less formaldehyde than do UF products;
- Select UF pressed wood products that are sealed with finishes that reduce formaldehyde emissions, such as veneer, vinyl, or other water-resistant coating;
- For UF pressed wood products, look for the Composite Panel Association (CPA) or Hardwood Plywood and Veneer Association (HPVA) stamps. Products bearing these stamps meet certain formaldehyde emission standards.⁶⁴

TURI's 2006 "Five-Chemical Alternatives Assessment" and other funded research projects has produced much information useful for the primary prevention approach of use reduction. TURI has published information on:

- Alternative methods for manufacturing phenolic resins, such as enzymatic water-based polymerization processes (based on horseradish peroxidase and soy peroxidase) and pyrolysis of biomass;
- Alternatives to the electroless copper process that uses formaldehyde;⁶⁵
- Replacements in textile treatments, such as glyoxal resins, butane tetracarboxylic acid, sodium hypophosphite, and polymeric carboxylic acid/citric acid;
- Water-based, ultra-violet cured and electron beam-cured coatings;
- Alternatives to using formaldehyde for sanitary storage in barbering and cosmetology;
- Alternative methods of preserving educational specimens for dissection;
- Alternatives in building panels.

⁶⁴ <http://www.arb.ca.gov/research/indoor/formaldfs08-04.pdf>.

⁶⁵ See U.S. Environmental Protection Agency's Design for the Environment Printed Wiring Boards Project, <http://www.epa.gov/dfe/pubs/pwb/pdf/ctsawire.pdf>.

Recommendations

Because formaldehyde has been designated as a Higher Hazard Substance, which lowers the threshold for coverage to 1,000 pounds per year (from 25,000 for manufactured or processed to 10,000 for otherwise used), the program will be conducting outreach to companies newly covered by TURA. In addition, Higher Hazard Substance designation triggers a statutory mandate to consider Priority User Segment (PrUS) designation, which would extend TURA coverage to companies using more than 1,000 pounds, but with less than ten employees (TURA otherwise exempts companies with less than ten employees). PrUS designation also provides the discretion to the Massachusetts Department of Environmental Protection to determine that it is necessary to apply some or all of the elements of TURA reporting and/or planning to all users of Higher Hazard Substances. In order to determine if PrUS designation is warranted, the program must consider six statutory factors, and the Administrative Council must rule within four years after Higher Hazard Substance designation. Because of these statutory mandates, the program will be researching where formaldehyde is used in industrial settings throughout the Commonwealth, and whether there are implementable options for use reduction. This effort will be collaborative with relevant organizations and experts, and updates will be publicly shared through TURA Advisory Committee and Administrative Council meetings.

OTA can offer assistance to the companies that have shown negative trends in use efficiency and can continue efforts to learn from the companies that have eliminated the use of formaldehyde and how they achieved those reductions (without violating confidentiality).

One area of research that the program may not have resources to conduct, but which would be useful to many, would be an evaluation of available certifications of low emission materials and an assessment of their utility and reliability for guiding purchases.⁶⁶ Evaluating and using available certifications is part of the Commonwealth's purchasing practices, informed by the Toxics Use Reduction program, and is useful in delivering assistance and educational services. Consumers are presented with a wide variety of sources of advice. Guidance on how to evaluate the reliability of the advice could be helpful, as some organizations employ transparency, avoid conflicts of interest, ensure updating and a sound scientific foundation, and undertake claims verification, while others do not.

For consumers, information on the formaldehyde-releasing characteristics of products is often not readily available, when it is they may not be able to judge whether it is reliable. Developing detailed advice for consumers on identifying formaldehyde content, and substances that release formaldehyde, could be an effective means of reducing instances of exposure and harm. Because there is a variety of sources, many unknown to consumers, a respected or authoritative entity could promote use reduction by compiling and making widely available reliable information guiding the purchasing of

⁶⁶ An example is the Green Label Plus program of the Carpet and Rug Institute, a testing program adopted in cooperation with EPA, which certifies if products meet standards set by California for indoor air quality. http://www.carpet-rug.org/documents/factsheets/CRI_GLP_factsheet.pdf.

products that might release formaldehyde into indoor environments, or come in contact with the skin. The new national regulations on emission standards from composite wood products will provide an opportunity to educate the public on a source of indoor air exposures and relevant primary prevention. It may be, as some claim, that levels of exposure to consumers are typically below established levels of concern. But it is important to reduce, wherever possible, the source of any contribution to cumulative exposure.

The TURA programs recently provided the Massachusetts Board of Cosmetology with recommendations to remove a requirement that “dry sanitizer” (para-formaldehyde, a solid form of formaldehyde) be used in drawers where hair brushes are kept, and the Board has proposed changes to accomplish this.

Chlorine

Chlorine is generally produced by a chemical process that creates both chlorine gas and the alkali sodium hydroxide (caustic soda), and thus the industry is often referred to as the “chlor-alkali” industry. Chlorine is a greenish-yellow gas, very reactive under certain conditions but not flammable or explosive, caustic soda is a translucent, white, crystalline solid. More than 13 million tons were produced in the U.S. in 2004.⁶⁷ According to the Agency for Toxic Substances and Disease Registry (ATSDR), the following effects have been observed in humans briefly exposed to chlorine:

- Mild nose irritation at 1–3 ppm
- Eye irritation at 5 ppm
- Throat irritation at 5–15 ppm
- Immediate chest pain, vomiting, changes in breathing rate, and cough at 30 ppm
- Lung injury (toxic pneumonitis) and pulmonary edema (fluid in the lungs) at 40–60 ppm
- Death after 30 minute exposure to 430 ppm
- Death after a few minute exposure to 1,000 ppm.⁶⁸

OSHA has established a permissible exposure limit of 1 ppm, and NIOSH has established a recommended exposure limit of 0.5 ppm as a Time-Weighted Average (TWA) for up to a 10-hour workday and a 40-hour workweek, and a short-term exposure limit (STEL) of 1 ppm. Uses include:

- Chlorinated solvents

⁶⁷ Chlorine Institute, <http://www.chlorineinstitute.org/News/newsdetail.cfm?ItemNumber=2498>.

⁶⁸ “The concentrations listed above are approximate; the effects will depend also on exposure duration. In general, people who suffer from respiratory conditions such as allergies or hay fever, or who are heavy smokers, tend to experience more severe effects than healthy subjects or nonsmokers.” Toxicological Profile for Chlorine, U.S. Dept. Health and Human Services, Public Health Service Agency for Toxic Substances and Disease Registry, 11/2010, p. 4, <http://www.atsdr.cdc.gov/toxprofiles/tp172.pdf>

- Automotive antifreeze and antiknock compounds
- Polymers (synthetic rubber and plastics)
- Resins
- Elastomers
- Pesticides
- Refrigerants
- Fluxing, purification, and extraction agent (metallurgy)
- Bacteriostat, disinfectant, odor control, and demulsifier (water treatment)
- Bleaching cellulose and artificial fibers
- Manufacture of chlorinated lime
- Detinning and dezincing iron
- Shrink-proof wool
- Pharmaceuticals
- Cosmetics
- Lubricants
- Flameproofing
- Adhesives
- Batteries containing lithium or zinc
- Hydraulic fluids
- Food processing
- Bleaching, cleaning, disinfecting (laundries, dishwashers)⁶⁹

Polyvinyl chloride manufacturing accounts for about one-third of U.S. production. This report includes chlorine gas and certain chlorine-containing compounds, for example sodium hypochlorite (bleach).

Use Under TURA

Use of chlorine gas by TURA-reporters in the state increased from 2000-2009 by 5,201,402 pounds, but all of the reported use was by one company: eleven other companies had stopped reporting pure chlorine use, a reduction of 7,735,398 pounds. No byproducts or releases were reported in 2009. Byproducts had been reduced by 3,244 pounds, releases by 412 pounds. Examining the more common chlorine compound, sodium hypochlorite, 47 companies reported in 2000 and only 25 companies reported use of the chemical in 2009. Due to a few very large users, amounts used increased by 142

⁶⁹ Occupational Safety and Health Guideline for Chlorine, OSHA, <http://www.osha.gov/SLTC/healthguidelines/chlorine/recognition.html>.

percent, but the generation of byproduct decreased to 74 percent of previous levels. Total releases and transfers were 0.2% of total use in 2000, and are now 0.1%.

TURA data provides the same picture for chlorine and bleach that is seen for isocyanates and formaldehyde: use of these chemicals has been reduced by TURA-covered companies, but TURA only provides information from a few of the many locations where the chemical is being used. Appendix Two contains information from TURA concerning use in 2009.

Uses Outside of TURA

It is well established that there are great benefits of chlorine use: for example, staff of the International Programme on Chemical Safety, World Health Organization, Geneva, Switzerland wrote in 1996 that risk assessments estimated that “the risk of death from known pathogens in untreated surface water appears to be at least 100-1000 times greater than the risk of cancer from known chlorination by-products, and the risk of illness from pathogens in untreated surface water appears to be at least 10,000 - 1 million times greater than the risk of cancer” from the by-products of chlorinating drinking-water.⁷⁰ However, it is possible to enjoy these benefits while reducing the risk of avoidable exposures. Chlorine’s use in many locations across the Commonwealth, at homes, in schools, in hotels, and under town and commercial management, may represent another significant opportunity to reduce the use of chemicals that may affect respiratory functioning.

This report focuses on two disinfection applications that are widespread, where there are indications that avoidable exposures can be reduced: pools and disinfection of hard surfaces. It is important to emphasize that this report does not recommend discontinuing the use of chlorine for disinfection, because the public health and safety risks of inadequate disinfection can be considerable. Rather, the report focuses on the importance of not overusing disinfectants in general, with chlorine being a prime example where ensuring the appropriate use – not more or less than necessary – will have critical benefits. The report also provides some information about alternatives that merit consideration, but does not suggest switching to them without careful and comprehensive assessment of risks, costs, and benefits.

Pools

Disinfection is necessary in order to prevent the spread of disease from exposure in pools, and chlorine is widely used for this purpose. The acute risks of handling various forms of chlorine chemicals are well-known,⁷¹ but chronic exposure to breathing chlorine compounds presents another concern, not as well understood. There are several forms of chlorine used in disinfecting pools: generally indoor pools use sodium hypochlorite (liquid bleach), calcium hypochlorite, or chlorine gas, and outdoor pools use

⁷⁰ “Chlorine in Water Disinfection”, Heng Galal-Gorchev, *Pure & App/ Chem.*, Vol. 68, No. 9, pp. 1731 -1 735, 1996.

⁷¹ See, for example: <http://www.cdc.gov/healthywater/swimming/pools/preventing-pool-chemical-injuries.html>

stabilized chlorine products. These various forms of chlorine then react with organic materials to form disinfectant byproducts (DBPs). (Swimming pool water has organic matter in it from the tap and from bathers: sweat, skin particles, hair, microorganisms, cosmetics, urine). All of these have different effects. Although disinfection is necessary for public health, according to a 2008 *Environmental Health Perspectives* article referenced by the Centers for Disease Control “traditional chemical disinfection processes result in the formation of disinfection by-products (DBPs),” the types and levels of which depend on numerous factors, including swimmer hygiene. “Swimming pool DBPs may include inorganic chloramines, organic chloramines, haloacetonitriles, and other organic compounds, some of which are volatile and known respiratory irritants...Swimmers would be exposed to these DBPs, as well as the pool chemicals used as disinfectants that are irritants. There is evidence that irritant chemicals may contribute to the incidence of asthma in children and adults.”⁷²

The Centers for Disease Control, in an advisory on improving fresh air intake to reduce exposure to DBPs, notes that “Irritants in the air at swimming pools are usually the combined chlorine by-products of disinfection...as the concentration of by-products in the water increases, they move into the surrounding air as well. Breathing air loaded with irritants can cause a variety of symptoms depending on the concentration of irritants in the air and amount of time the air is breathed. The symptoms of irritant exposure in the air can range from mild symptoms, such as coughing, to severe symptoms, such as wheezing or aggravating asthma. It is also known that routine breathing of irritants may increase sensitivity to other types of irritants such as fungi and bacteria.”⁷³

Several studies have observed increased risk of childhood asthma associated with indoor and outdoor pool attendance.⁷⁴ However, other studies have not been able to replicate these findings.⁷⁵ Some studies find a mixed picture (not enough information to draw conclusions concerning dose-response,⁷⁶ not enough evidence to draw conclusions about causal relationship).⁷⁷ The 2009 *Environmental Health Perspectives* article notes areas for further study: “In addition to chloramines, other chemical and/or

⁷² Weisel, et al., “Childhood Asthma and Environmental Exposures at Swimming Pools: State of the Science and Research Recommendations”, *Environ Health Perspectives*, 117:500-507, 2009.
<http://ehp03.niehs.nih.gov/article/info:doi/10.1289/ehp.11513>.

⁷³ <http://www.cdc.gov/healthywater/swimming/pools/irritants-indoor-pool-air-quality.html>.

⁷⁴ See: Bernard A, Carbone S, de Burbure C, Michel O, Nickmilder M. “Chlorinated pool attendance, atopy, and the risk of asthma during childhood”, *Environ Health Perspect* 2006;114:1567–1573; Bernard A, Nickmilder M, Voisin C. , “Outdoor swimming pools and the risks of asthma and allergies during adolescence”, *Eur Respir J* 2008;32:979–988; Bernard A, Nickmilder M, Voisin C, Sardella A., “Impact of chlorinated swimming pool attendance on the respiratory health of adolescents”, *Pediatrics* 2009;124:1110–1118.

⁷⁵ See: Schoefer Y, Zutavern A, Brockow I, Schafer T, Kramer U, Schaaf B, Herbarth O, von Berg A, Wichmann HE, Heinrich J., “Health risks of early swimming pool attendance”, *Int J Hyg Environ Health* 2008;211:367–373; Font-Ribera L, Kogevinas M, Zock JP, Nieuwenhuijsen MJ, Heederik D, Villanueva CM, “Swimming pool attendance and risk of asthma and allergic symptoms in children”, *Eur Respir J* 2009;34:1304–1310.

⁷⁶ <http://ajrccm.atsjournals.org/content/183/5/582.long>.

⁷⁷ <http://www.ncbi.nlm.nih.gov/pubmed/18951254>.

biological agents present in the indoor pool environment could potentially affect the respiratory system and may contribute to an association between adverse health outcomes and time spent at indoor pools. These other agents should be identified and quantified, where possible, and investigated for allergenicity and irritant properties. For example, new research has identified other volatile DBPs, including dichloroacetonitrile and dichloromethylamine (Li and Blatchley 2007). Dichlorooxide (Cl_2O), which is present in liquid bleach and contributes to the “chlorine” odor, warrants further investigation. Dichlorooxide can be measured with high-resolution ultraviolet spectroscopy (Cady et al. 1957), but no onsite method for indoor pool environments is available.”

Exposure to chlorine is known to cause irritant asthma,⁷⁸ but the question of whether or not to engage in efforts to reduce toxics use does not depend on whether all DBPs or all forms of chlorine-based disinfection can be directly associated with asthma. A recent overview recommends more research to better characterize the relationship and “in the short term *to determine how to reduce DBPs at indoor swimming pools*” (emphasis added), and providing “better education and improved test methods for pool operators on pool chemistry to promote understanding of the chemical consequences of overdosing or underdosing of pool water.”⁷⁹

Another recent overview commenting that recent findings are “distinctly reassuring as regards the safety of indoor swimming pools for children,” stated that “we cannot disregard the health risks of excessive exposure to chlorine derivatives due to *unnecessary overchlorination of the water* (emphasis added) or to acute chlorine inhalation caused by swimming pool accidents. Every effort should be made to minimize the potential hazards of higher than necessary disinfection by product (DBP) levels.”⁸⁰ They also note that individual response is variable, continued study is necessary to identify children who might be more vulnerable to lung damage in the swimming pool environment, airway damage may be occurring in adolescent elite swimmers as well as adults, and “deeper insight on the effects of chlorine exposure in children over time is therefore definitely warranted”. Nothing in this report should be interpreted as discouraging swimming, but is intended to motivate greater attention to proper disinfection techniques and means of reducing exposure to possibly harmful chemicals.

There are two basic strategies for avoiding unnecessary overchlorination and reducing levels of DBPs: employing proper pool care or using alternatives to chlorination (including the strategy of using them in tandem with chlorination, to reduce the need for chlorine). Information about proper pool care is easy to find, and numerous sources recommend:

- Testing both free and total chlorine in the pool;

⁷⁸ Malo and Chan-Yeung (Lit Review; Malo J-L, Chan-Yeung M): Malo J-L, Chan-Yeung M. Appendix: Agents Causing Occupational Asthma with Key References. In: Bernstein LI, Chan-Yeung M, Malo J-L, Bernstein DI (eds). *Asthma in the Workplace*. 3rd Ed. New York: Taylor & Francis, 2006.

⁷⁹ Weisel, et al., “Childhood Asthma and Environmental Exposures at Swimming Pools”, op.cit.

⁸⁰ Placentini, Baraldi, *Am. J. Respir. Crit. Med.*, March 1, 2011, vol. 183, no. 5, 569-570.

- Record-keeping on maintenance and water quality monitoring;
- Educating swimmers on the importance of showering before entering the pool;
- Filtration to remove organic constituents;⁸¹
- Ensuring good ventilation of indoor air, as high levels of DBPs in the water causes higher levels in indoor air, and vice-versa;
- Adding enzymes to reduce phosphates, which inhibit chlorine effectiveness;⁸²
- Controlling for pH, hardness;
- Regular “shocking” of the pool.

Shocking refers to the practice of adding a chemical to destroy chloramines, considered the cause of the irritation and smells that trigger complaints from bathers. It is typically performed with sodium hypochlorite (bleach, or NaClO), which comes in powder, liquid and tablet form, but it may also be accomplished with nonchlorine chemicals. In order to know how much shocking chemical to add, it is necessary to use measurement methods that can distinguish between free and total chlorines. If shocking by adding chlorine, it is important to note that adding too little or too much chlorine can lead to additional problems.⁸³ Most importantly, the authors of the 2009 *Environmental Health Perspectives* article note that “the ‘combined chlorine’ in swimming pools can often be dominated by organic chloramines and the responses of these compounds to existing shock chlorination practices are largely unknown.” The assumptions used to guide shocking practices “apply to analyses of water samples from well-maintained pools, where the true inorganic chloramine concentration was quite low, and all quantifiable inorganic combined chlorine was present in the form of trichloramine. It is likely that the combined chlorine residuals in poorly maintained pools will be more complex.”

The authors of the 2009 *Environmental Health Perspectives* article recommended minimum training for all pool operators that includes:

- Standardized methods for measuring the chemical content of water;
- A minimum number and frequency of water tests to establish whether a pool disinfectant is maintained at the optimal levels;

⁸¹ Typically through recirculation, but it is also possible to treat pool water in a tank and to filter out insoluble DBPs before pumping water into the pool. (Granulated Activated Carbon filters can be used to remove soluble DBPs).

⁸² A grant program of the Maine Department of Environmental Protection for use of a food-grade enzyme led to significant chlorine reductions at two pools: http://www.pressherald.com/news/chlorine-use-takes-a-dive-in-public-pool-experiment_2010-12-20.html. However, OTA has received comments from the American Chemistry Council that “Swimming pool industry experts do not agree that phosphates inhibit chlorine effectiveness” and noting that enzymes could react with chlorine, “reducing chlorine’s availability for disinfecting”.

⁸³ It is often recommended that bathers not reenter the pool until chlorine levels have dropped to 4 ppm or less. The Department of Public Health’s Minimum Standards for Swimming Pools (State Sanitary Code: Chapter V) in section 435.29 Chemical Standards provides for a range of 1-3 ppm. It is also important to use equipment that feeds a precise amount carefully, rather than to simply add chlorine tablets (or “sticks”), which could cause failure of the pump or damage the filters.

- The importance of proper ventilation of indoor pools.

The Centers for Disease Control lists several resources for pool training,⁸⁴ including the Certified Pool Operator course provided by the National Swimming Pool Foundation (NSPF),⁸⁵ and is working with the NSPF and many others to develop a consensus Model Aquatic Health Code (MAHC) to address the absence of a uniform, national standard for pool operation.⁸⁶ The MAHC would be available for adoption by state and local authorities. The draft concerning operator training proposes that for certain pools, such as those run by municipalities or schools, or with more than 200 patrons daily, that a qualified operator be onsite during all hours of operation, and that other pools have a qualified operator on contract for periodic checks on quality, and a responsible supervisor on site capable of testing and maintaining water quality.⁸⁷ The draft training covers testing, ventilation, DBPs, and secondary disinfection, such as ozonation or ultraviolet light, which can be used to reduce the levels of chlorination that are needed for disinfection.

Concerning alternatives to using chlorine, or means of using less, several are in use. Some of them can be used in conjunction with chlorine, taking advantage of chlorine's effectiveness in disinfection, but reducing the levels needed.

Bromination

Bromine works similarly to chlorine, though with some differences in disinfecting capabilities. It may be preferred for swimmers with sensitive skin, and its use reduces concerns about odor. It is handled in a similar manner to chlorine, but there are differences in maintenance. It costs more than chlorine, but can be more long-lasting in indoor environments (outdoors, it is more sensitive to sun).

Salt

The process of saltwater chlorination involves using electrolysis to break down salt. The products of the resulting chemical reaction are hypochlorous acid (HClO) and bleach. Users and vendors claim that this method of chlorination reduces chemical use and the chemicals that cause irritation and odor. For example, a Wall Street Journal article noting that 13 percent of pools in the U.S. use salt water chlorination, stated that the method "doesn't allow the formation of itch- and stink-producing byproducts that conventional chlorine pools produce."⁸⁸ Some disadvantages of saltwater chlorination include the fact that the salt used is corrosive and may damage some metals; the stainless steel

⁸⁴ <http://www.cdc.gov/healthywater/swimming/pools/pool-operator-training.html>.

⁸⁵ <http://nspf.org/en/cpo.aspx>.

⁸⁶ <http://www.cdc.gov/healthywater/swimming/pools/mahc/>.

⁸⁷ <http://www.cdc.gov/healthywater/pdf/swimming/pools/mahc/structure-content/mahc-module-6.1-operator-training-code.pdf>.

⁸⁸ "Worth Their Salt? Pools where Chlorine Isn't King". *WSJ*, August 24, 2011.

<http://online.wsj.com/article/SB10001424053111903461304576526201430239750.html>.

products which are damaged by saline pools may not fall under the warranties of the pool equipment manufacturers; and high initial cost of the system, maintenance and replacement parts.

Ultraviolet Radiation

Short wavelengths of UV light can be used to destroy the DNA of, and therefore kill, microorganisms present in swimming pool water. UV irradiation does not leave behind chemicals, odors or color. When using UV irradiation, it is possible to reduce chlorine use by a significant amount (the UV system company SpectraClear UV states that its product has the ability to eliminate up to “90 percent of chlorine used in traditional chlorinated pools.”⁸⁹ However, the effectiveness of UV light in breaking down micro-organisms is dependent on “line of sight exposure,” and water treated by UV irradiation is not resistant to re-infection – no residual UV effect is present in the pool water for an extended period of time. It is recommended by the Model Aquatic Health Code’s Disinfection and Water Quality Module to be used in conjunction with chlorine, which provides continued disinfection.

Ozonation

In the process of ozonation, oxygen from air is concentrated and passed through a high voltage electric discharge, which creates ozone gas that is pulled (by a vacuum) into the water being treated.⁹⁰ When ozone is added to swimming pools, the degradation rate of organic matter is increased, reducing the formation of dangerous byproducts, such as THMs and chloramines, as well as the amount of chlorine needed for disinfection. The amount of water used can also be reduced since the quality of water is being improved, and odor and eye irritation issues can be eliminated. Ozone is not powerful enough as a disinfectant to be used without some chlorine, and due to ozone’s limited activity time in swimming pool water, it can only destroy pathogens introduced by swimmers in the pool for a short period of time. It is recommended by the Model Aquatic Health Code to be used in conjunction with chlorine. Pools may be retrofitted to use ozonation to reduce the need for chlorine.⁹¹

Ionization

Disinfection through copper and/or silver ionization works by sending an electric current through the metals to release ions into pool water, which work as disinfectants. Copper and silver ions are noncorrosive and have a greater residual effect than UV and ozone. Chlorination is still necessary for maximum disinfection, because the ions kill but don’t oxidize organic materials, though as with UV and ozonation, significantly lower amounts of chlorine are needed. There is a possibility of slight blue-

⁸⁹ <http://www.spectractableuv.com/BenefitsElimChlorine.html>.

⁹⁰ <http://www.water-research.net/ozone.htm>.

⁹¹ http://www.envronozone.com/swimming_pools/ozone_swimming_pools_german_din.htm

green staining from copper, and black from silver, and discharges from the pools will contain the ions. Massachusetts has issued an Environmentally Preferable Purchasing contract for pool ionization.⁹²

Use in Sanitizing Surfaces

Chlorine is also widely used in many locations as a disinfectant, and according to some observations, sometimes overused.⁹³ The San Francisco Asthma Task Force has developed initiatives to reduce the use of bleach in cleaning, responding to concerns expressed by the public and finding that “ongoing statewide surveillance from 1993 to the present links bleach to work-related asthma (77 WRA cases of 4417).”⁹⁴ There are many others who have focused on exposures to chlorine, accidental and routine, from the use of bleach in cleaning, and it is standard to provide warnings on not mixing bleach with ammonia or acids, as noxious gases will form.

This report does not discuss whether bleach is the best product to use for the purpose of disinfection. Concerns have been raised about many disinfectants. For example, a popular substitute for bleach, quaternary ammonium compounds, have also been associated with asthma.⁹⁵ The Council of State and Territorial Epidemiologists (CSTE) wrote to the Centers for Disease Control in 2011 that “Cleaning products have emerged as a significant respiratory hazard for workers. More than 40 articles have documented both new onset asthma and exacerbation of existing asthma related to use of cleaning products among those using the products and bystanders in the area.”⁹⁶

The CSTE letter notes that “Epidemics of SARS and H1N1 have added to the concern about bacteria and virus mediated illnesses, especially among children. Fear has grown about the risks of disease transmission from contaminated surfaces in homes and schools, fueled in part by marketers of cleaning products. Many companies have added disinfectant ingredients to their cleaning products, claiming unsubstantiated health benefits (Jefferson 2009). Parents have demanded ‘disinfection’ of schools following disease outbreaks seeking ways to protect their children.”

While substantial evidence exists concerning the value of handwashing, “Little is known about hand to surface contact in schools and home... Despite the absence of proof about disease transmission from hand contact with ‘contaminated surfaces,’ methods to prevent disease transmission by disinfecting

⁹² <http://www.mass.gov/anf/budget-taxes-and-procurement/procurement-info-and-res/procurement-prog-and-serv/epp-procurement-prog/green-products-and-serv/specific-epp-statewide-contracts/pool-ionization.html>.

⁹³ For example, the interagency committee which oversees the implementation of Governor Patrick’s Environmentally Preferable Products (EPP) Executive Order has determined that there is a need to train state employees in the appropriate use of disinfectants: <http://www.mass.gov/anf/budget-taxes-and-procurement/procurement-info-and-res/procurement-prog-and-serv/epp-procurement-prog/publications-rpts-and-tools/reports-and-handbooks.html>. The Commonwealth’s EPP program has also made hydrogen-peroxide based and other alternatives available for state and municipal agencies.

⁹⁴ Bleach Exposure in Child Care Settings: Strategies for Elimination or Reduction: Report of the San Francisco Asthma Task Force, Agana, et al., 2011.

⁹⁵ For example, Purohit, et al., “Quaternary ammonium compounds and occupational asthma”, Service de Pneumologie, Hôpital Lyautey, Hôpitaux Universitaires de Strasbourg, France, <http://www.ncbi.nlm.nih.gov/pubmed/11007347>.

⁹⁶ <http://www.cste.org/ps2011/11-OH-01.pdf>.

these surfaces have been proposed, promoted and frequently implemented. Arif (2003) found that cleaning workers reported using 66 products, with 48 different respiratory irritants and sensitizers.” The letter concludes that routine disinfection of kitchens is not evidence-based, and “There is an absence of evidence that routine disinfection in the home will help prevent bacterial and viral disease. There is evidence that use of cleaning products, and disinfectants, harms health, increasing both the risk for developing and aggravating pre-existing asthma and allergic disease.” It may be that some of those charged with cleaning in places where infectious agent transfer is highly likely, such as day-care facilities, schools, hospitals, or public bathrooms, labor under the misconception that more is better, when it is the appropriate amount – not too much, nor too little, that is important.

Whatever disinfectant is used, it is not only important to use it effectively, but to avoid overuse. The standard advice of cleaning experts is to use soaps, detergents, or plain water to clean, and to reserve the use of disinfectants for necessary applications. Disinfectants in general are more dangerous than cleaners, because they are selected or formulated specifically for their ability to kill microorganisms. By following the standard advice of cleaning experts to use soaps, detergents, or plain water to clean, and reserving the use of disinfectants for post-cleaning, and only using them where necessary, use of this more dangerous class of chemicals can be reduced.

Recommendations

The TURA program, relevant agencies and other interested parties have begun collaborating to develop information on appropriate disinfection practices, to reduce the use of disinfectants as cleaners, and on the availability of safer disinfectant products and cleaning practices. This effort is occurring in conjunction with the state’s Environmentally Preferable Products program, administered by the Commonwealth’s Operational Services Division. This effort can provide the foundation for wider outreach to raise awareness of how to disinfect effectively, without underuse or overuse.

The relevant Council agencies should consider how to collaborate to develop and provide information for the public concerning proper chlorination of pools and means of reducing unnecessary exposures from chlorination, while maintaining the proper uses necessary to protect public health. This information can include products tailored for specific audiences, such as managers of pools in hospitality facilities, schools, private homes, and public grounds.

Conclusions

Health studies show that the incidence of asthma is trending upwards. The personal and economic impacts are increasingly being recognized as significant. The Toxics Use Reduction program has demonstrated that reductions in the use of toxic chemicals, including asthma-related chemicals, have been accomplished when users have turned their attention to the availability of options for reducing use. The agencies of the Commonwealth and other interested parties have an opportunity to reduce the incidence and exacerbation of asthma by focusing on the strategy of promoting the reduction in use of asthma-related chemicals in settings where risks of exposure occur. Concerning the use of chemicals by companies covered under TURA, OTA, TURI and DEP should continue to analyze trends and the individual performance of facilities reporting under TURA in order to focus program efforts, target offers of assistance, and/or to invite facilities to share information about what they have accomplished. The agencies should act to prompt greater efforts to reduce and to increase awareness of successful reductions or safer substitutions by companies covered, or potentially covered, under TURA. The program should also devote attention, and work with relevant entities, on increasing awareness of the importance of exposures resulting from chemical uses not covered by TURA, and the availability of opportunities for reductions in use and exposure risks.

Isocyanates

Information on the appropriate means of using spray urethane foams and other products containing isocyanates, such as coatings and adhesives, should be widely disseminated. Of particular importance is available training recommended by several government agencies and industry sources. Information should be developed and provided to help small companies, small contractors, and consumers recognize the need for appropriate cautions, and to increase knowledge of safer alternatives.

Formaldehyde

In addition to the work that the program will be doing concerning outreach to companies newly covered under TURA due to the designation of formaldehyde as a Higher Hazard Substance, and the mandatory consideration of Priority User Segment designation, information could be developed and provided concerning emissions from products that are widely used, such as composite woods, cosmetics, or textiles. The public should be assisted in understanding the reliability, accuracy and relative importance of the various certifications and measurements that exist.

Chlorine

Efforts to develop information concerning proper means of disinfecting surfaces, to avoid excessive use, should be continued and expanded. Information should also be developed and provided concerning proper chlorination of pools and means of using lower levels of chlorine, to avoid excessive use. The certification and model code developed by the Centers for Disease Control and the National Swimming Pool Foundation represents a significant opportunity.

For all three of the chemicals above, it will be necessary to identify the affected populations and the means of reaching them with the information that can help them reduce use and thus the risk of exposures. Reducing use in industry can improve productivity and help avoid the personal suffering that results not just from disease incidence but also from work limitations. Reducing exposures in households can help reduce the incidence of asthma in children.⁹⁷ The Commonwealth can act to stem the rise in respiratory dysfunction and save on medical care costs by acting to ensure that users of asthma-related chemicals have information about alternatives and the most effective means for reducing the incidence of harm: reducing the source of exposures.

⁹⁷ Annually, 10.5 million school days are missed as a result of asthma. *The President's Task Force on Environmental Health Risks and Safety Risks to Children: Coordinated Federal Action Plan to Reduce Racial and Ethnic Asthma Disparities*, http://www.epa.gov/childrenstaskforce/actionplan_one_pager.pdf.

Appendix One

Survey on Asthmagen Use Reduction

Please provide sufficient detail so that someone else would be helped to achieve similar results.

Please check the underlined spaces and provide details where appropriate.

1. **We substituted another material for one that causes or exacerbates asthma** ____ (check if yes).
 - a. What function did (the asthmagen) perform? (Such as, cross-linking, stabilizing, reactant, preservative).
 - b. Did you find a nonchemical method for performing that function?
 - c. What is the chemical that has replaced (the asthmagen)? If you can't name the chemical, please describe it, or the class of chemicals to which it belongs.
 - d. Does the substitute perform as well as (the asthmagen)?
 - e. Are there special conditions that are necessary for the substitute chemical to work? (Please explain, noting especially if the substitute performs better).
 - f. Does the substitute have comparable cost? (Please note both upfront purchase and subsequent management costs, such as disposal, workplace safety precautions, or regulatory compliance, and please note savings, using a life-cycle perspective. A quantitative analysis is not necessary, just reasonable estimates).
 - g. Does using the substitute require new equipment or changes in equipment, training, or other actions? Please describe.
 - h. Did using the substitute present any problems of customer or worker acceptance? If so, how did you address them?
 - i. Other. Please note any other consequences of making the change.
2. **We changed operations to reduce use** ____ (check if yes)
 - a. Were reductions in use achieved through better measurement? If so, how did you implement improved measurement? Was it at the stage of initial chemical input, or later in the process? Was it measurement of quantities used or measurement of a process parameter?
 - b. Were reductions in use achieved through successful trial of reduced quantities? (Including simply experimenting to see if using less worked just as well)
 - c. Were reductions in use achieved through use of a catalyst, reactant, or changes in substrate or other materials used in making the product? Please explain.
 - d. Were reductions in use achieved by improving equipment?

- e. Were reductions in use achieved through more careful operations (besides measurement), such as training, changes in transfer, containment, mixing time, enclosure to prevent evaporation?
- f. Other (please describe)

3. We reduced byproduct ____ (check if yes)

- a. Byproduct was reduced because we reduced input. (Please explain)
- b. Byproduct was reduced because of improvements in equipment. (Please explain)
- c. Byproduct was reduced because of improvements in operation. (Please explain)
- d. Other means that byproduct was reduced. (Please explain)

4. We reduced releases ____ (check if yes)

- a. Releases were reduced because of reductions in use. (Please explain)
- b. Releases were reduced because of reductions in byproduct. (Please explain)
- c. Releases were reduced because of the use of control equipment. (Please explain)
- d. Releases were reduced because of improvements in control or treatment. (Please explain)

5. We reduced exposures ____ (check if yes)

- a. Exposures were reduced by improving ventilation. Please provide some detail: spot ventilation? Increased air changes? Does the ventilation have energy recovery?
- b. Exposures were reduced by enclosing operations. Partial (such as doorway barriers)? Complete (such as glove box)? Please describe.
- c. Exposures were reduced by changing the process to avoid offgassing or volatilization in work areas. Please provide more information about how this was achieved, if it was not already described above (reducing releases and/or byproduct).
- d. Exposures were reduced by providing personal protective equipment. (Please describe)

6. We have plans to implement Asthagen Use Reduction (AUR) ____

- a. When were these plans initiated?
- b. What was the initiating factor? (Read reports, managerial policy, staff-led, occupational risk assessment, word-of-mouth, this survey)
- c. Please describe. (Meetings held, research done or contemplated, policy communicated)

7. AUR proposals have been made, but have not been implemented. ____ (check if yes)

Proposals were made in some form or manner, to substitute materials, change operations, reduce byproduct, reduce releases and/or reduce exposures, but were not implemented. (Please describe the

proposed action(s) and why it was (they were) not implemented). *Please read note below before responding.*

8. AUR proposals are still under consideration. _____ Please explain what might increase the likelihood of implementation of AUR methods at your facility, or at other facilities?

9. No AUR proposals have been made at this facility. ____ (check if yes)

Please examine these sample reasons, and then answer in your own words.

- It was too expensive
- It was technically infeasible
- We don't have the physical space for it
- It would have been too time-consuming to implement
- It might have interfered with efficiency of production
- It might have reduced the quality of our product
- It might have changed the quality of our product and raised questions of customer acceptance
- The issue of asthmagenicity is new and we have not factored it into our decision-making before
- The issue of asthmagenicity has not been a priority consideration at this facility We have not yet had time to fully understand the issue of asthmagenicity and options for addressing it, although we would like to
- There is no indication that anyone is being impacted by the use of these chemicals at our facility

10. Are there actions the state or federal government can take to increase the likelihood that manufacturers and others would be able to implement AUR?

11. How many employees are at the facility?

12. What is the relevant product or products in which the asthmagen is or was used? What are the relevant processes?

We thank you for your response to this survey. To receive TURP CE credits, submit your name, email or phone, and address. Minimal, adequate responses will receive 1 credit. Responses that provide information useful in understanding how AUR may be accomplished, including what barriers to implementation may exist and how they may be overcome, will receive more credits. Only those filling out the survey completely, and then responding to follow-up questions, can receive three credits. Unless you give permission for attribution, responses will be confidential and only aggregated, generic information will be released.

As you may know, OTA provides free and confidential assistance, and if you would like us to help you to achieve more reductions, (or reduce the use of other toxic chemicals, or the use of energy or water),

please contact us. The results of this survey will be presented to the TUR Administrative Council, which is chaired by the Executive Office of Energy and Environmental Affairs and has representatives of the Commissioner of Environmental Protection, the Secretary of Housing and Economic Development, the Secretary of Public Safety, the Director of Labor and Workforce Development, and the Commissioner of Public Health.

If you wish to be recognized for your achievements, please let us know. We will consider producing a case study, or other publication, or using your story in our workshops and conferences (let us know if you wish to be the presenter, or have a recommendation for a presenter, or would like to collaborate on an article).

If you have any questions about this survey, please do not hesitate to call Rick Reibstein (at OTA), 617 626 1062, or email rick.reibstein@state.ma.us.

Appendix Two

SUMMARY Data from TURA of Use in 2009

| TURA DATA ISOCYANATES 2009 | | | | | |
|-------------------------------------|--------------------------|--------------|---------------|----------------|---------------|
| Company | Chemical Name | Usage | Byprod | Release | Transf |
| Acushnet Company | Diisocyanates | 101892 | 3381 | 0 | 3381 |
| Advanced Urethane Technologies Inc | Toluene Diisocyanate C | 5323121 | 135 | 135 | 0 |
| Allcoat Technology Inc | Diisocyanates | 109738 | 243 | 28 | 830 |
| Allcoat Technology Inc | Toluene Diisocyanate C | 75054 | 38 | 38 | 0 |
| Avecia Inc | Diisocyanates | 1645267 | 16632 | 14 | 16618 |
| Avecia Inc | Toluene 2,6-Diisocyanate | 93197 | 33 | 0 | 0 |
| Avecia Inc | Toluene 2,4-Diisocyanate | 378714 | 29 | 0 | 0 |
| Bostik Inc | Diisocyanates | 199332 | 3870 | 5 | 3870 |
| C L Hawthaway & Sons | Diisocyanates | 473407 | 0 | 0 | 0 |
| Callaway Golf Ball Operations, Inc. | Diisocyanates | 101920 | 12862 | 0 | 12862 |
| Cold Chain Technologies Inc | Diisocyanates | 180200 | 0 | 0 | 0 |
| General Electric Company | Diisocyanates | 41250 | 910 | 0 | 0 |
| Heat Transfer Products | Diisocyanates | 220152 | 45 | 10 | 0 |
| ITW Devcon Plexus | Diisocyanates | 36203 | 2428 | 0 | 2482 |
| Key Polymer Corp | Diisocyanates | 58308 | 1267 | 44 | 0 |
| Lubrizol Advanced Materials Inc | Diisocyanates | 1620234 | 40778 | 110 | 40506 |
| New Balance Athletic Shoe Inc | Diisocyanates | 118994 | 0 | 0 | 0 |
| Palmer Foundry Inc | Diisocyanates | 16954 | 1 | 0 | 0 |
| Quabaug Rubber Company | Diisocyanates | 48450 | 0 | 1.82 | 0 |
| Resin Technology Group LLC | Diisocyanates | 57372 | 1211 | 5 | 1211 |
| Stahl USA | Diisocyanates | 264032 | 287 | 0 | 0 |
| Union Specialties, Inc. | Diisocyanates | 639564 | 5 | 5 | 0 |
| Wollaston Alloys Inc | Diisocyanates | 57611 | 6 | 0 | 6 |

| TURA DATA FORMALDEHYDE 2009 | | | | |
|---------------------------------------|--------------|---------------|----------------|---------------|
| Company | Usage | Byprod | Release | Transf |
| Boremco Specialty Chemicals | 72905 | 1 | 0 | 0 |
| Dow | 307347 | 5365 | 10 | 5365 |
| Ineos Melamines (claims trade secret) | | | | |
| MW Custom Papers | 44879 | 44879 | 6234 | 239 |
| Raytor Compounds Inc | 1001513 | 1726 | 1164 | 562 |
| Suddekor LLC | 42400 | 2290 | 2285 | 5 |
| The Dodge Company | 889402 | 6161 | 3395 | 2766 |

| TURA DATA CHLORINE 2009 | | | | |
|---|--------------|---------------|----------------|-------------|
| Company | Usage | Byprod | Release | Xfer |
| Boremco Specialty Chemicals | 12936800 | 0 | 0 | 0 |
| TURA DATA Sodium Hypochlorite 2009 | | | | |
| Crown Uniforms | 10961 | 6576 | 0 | 6576 |
| National Metal Finishing Corp | 17295 | 0 | 0 | 0 |
| PureCoat North LLC | 11353 | 2270 | 0 | 2270 |
| Texon USA | 15880 | 0 | 0 | 0 |
| Yoplait Colombo | 11830 | 11830 | 0 | 0 |
| Sodium Hypochlorite | Usage | Byprod | Release | Xfer |
| Alpha Chemical Services Inc | 124579 | 0 | 0 | 0 |
| Borden & Remington | 14786686 | 3593 | 3593 | 0 |
| Churchill Linen Service Inc | 27037 | 10057 | 0 | 0 |
| Crane & Co Inc Pioneer Mill | 947085 | 881755 | 0 | 0 |
| Dominion Energy Brayton Point LLC | 402768 | 0 | 0 | 0 |
| Eastman Gelatine Corporation | 48000 | 0 | 0 | 0 |
| Entergy Nuclear Generation Company | 87113 | 0 | 0 | 0 |

| | | | | |
|---------------------------------|---------|-------|------|-------|
| Erving Paper Mills Inc | 547609 | 0 | 0 | 0 |
| James Austin Co | 6061535 | 27407 | 2 | 27407 |
| Kraft Foods Global Inc | 43920 | 15 | 0 | 0 |
| Medical Area Total Energy Plant | 17775 | 0 | 0 | 0 |
| Millennium Power | 23546 | 181 | 0 | 181 |
| New Method Plating C | 26043 | 26043 | 0 | 0 |
| Ocean Spray Cranberries Inc | 27899 | 8082 | 0 | 0 |
| Purity Services Inc | 19785 | 0 | 0 | 0 |
| Rust Oleum Corp | 993537 | 4169 | 4169 | 0 |
| Seaman Paper Company | 754611 | 0 | 0 | 0 |
| Webco Chemical Corp | 571250 | 474 | 0 | 0 |
| Westfield Electroplating Co | 42808 | 42808 | 0 | 500 |
| Wheelabrator North Andover Inc | 100895 | 1 | 1 | 0 |

Using the Pivot Tables

This guide is intended as a supplement to the Chlorine, Formaldehyde, and Isocyanate spreadsheets posted on the OTA website. They can be found at respectively:

<http://www.mass.gov/eea/docs/eea/ota/software/pivot-table-chlorine-2000-2010.xlsx>

<http://www.mass.gov/eea/docs/eea/ota/software/pivot-table-formaldehyde-2000-2010.xlsx>

<http://www.mass.gov/eea/docs/eea/ota/software/pivot-table-isocyanates-2000-2010.xlsx>

The pivot tables and charts and what they contain

Pivot Tables are used to contain data in a manner that allows the user to choose how that data will be viewed. The viewer of a Pivot Table chooses how the data is to be displayed by changing filters on the rows and columns.

For example, if one stored in a pivot table all the weights of 100 people over five years time, and a record of how many calories they ate, and how much they exercised during that time, one could adjust the filters to provide trendlines in weights, diets and/or exercise for one person over that time, or for all 100, or for any smaller group, over any subset of the time period. Pivot tables allow you to choose what you want a data set to present.

The Pivot Tables provided in this report contain a record of chemical use reports submitted by companies covered by the Massachusetts Toxics Use Reduction Act. The tables contain annual sums of formaldehyde, chlorine, and isocyanates used from 2000 – 2009 by companies in Massachusetts with more than ten employees and classified in an industrial sector. The tables also contain data on how much of that use became “nonproduct output” – byproduct of some kind. This includes waste material collected for disposal or recycling that is not integral to the product, emissions to air, and discharges to water. The tables also contain data on how much of the chemical was released.

A viewer can use these tables to examine trends in use, byproduct and/or releases by one particular company, or by all companies. The tables also contain production ratios, which are measures of how production changed at a facility. If a company’s use doubles over time, and its production ratio also doubled, then its use of the chemical per each unit of product produced has not changed. Although the company’s overall use has gone up, its efficiency of use has remained the same. These values can be calculated for individual companies using the data in these charts. Another measure of efficiency is the amount of chemical use compared to the amount of byproduct produced. We have included charts and tables of “byproduct/use” ratios.

Viewing the Pivot Tables

Each spreadsheet contains different worksheets that can be accessed by the tabs on the bottom left corner of the window. The tabs are labeled by their contents – ‘Table’ refers to the Pivot Table, and ‘Chart’ refers to the corresponding graph that you produce when you modify the filters. The worksheet tabs are color-coded; within each spreadsheet, linked tables and charts are the same color to allow for easier manipulation to create different graphs.

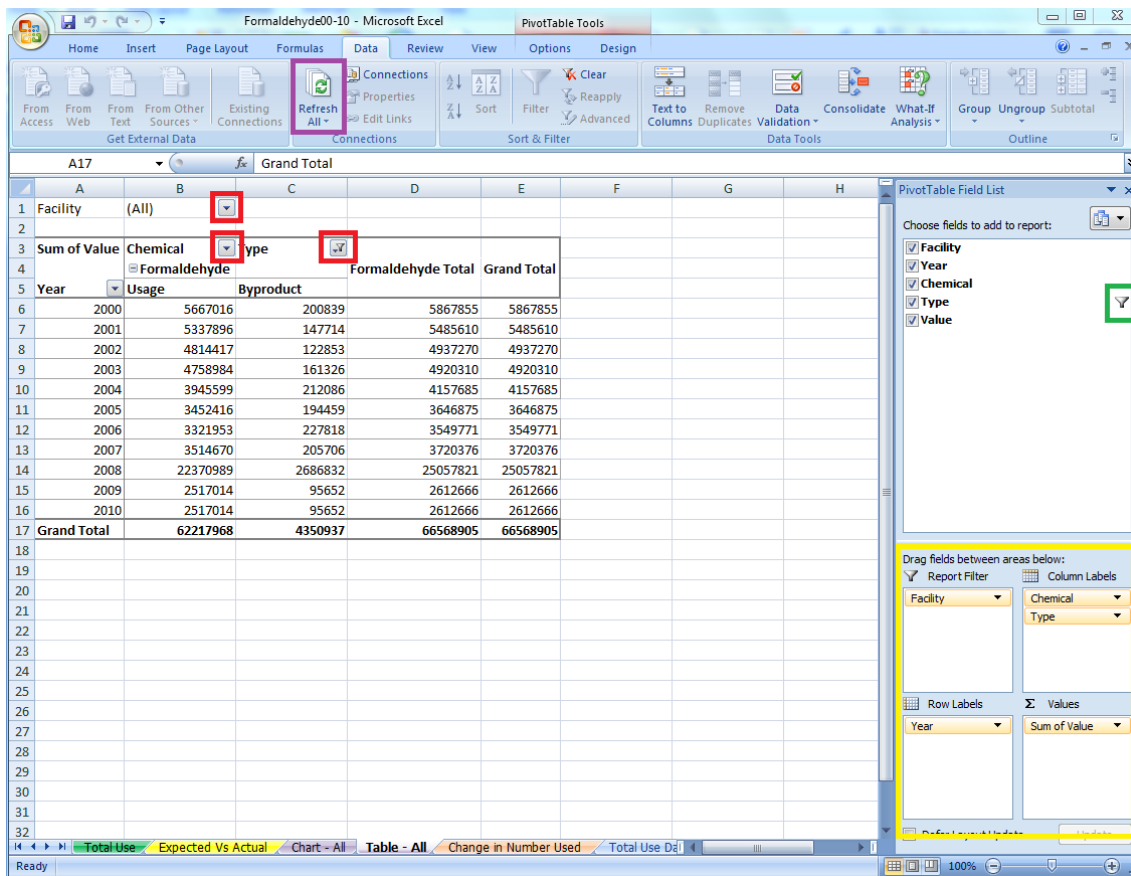


FIGURE 1. A TYPICAL VIEW OF A PIVOT TABLE. KEY COMPONENTS ARE HIGHLIGHTED.

The basic components of a Pivot Table are fields and filters. If they are not visible, as seen in Figure 1, one can access these components by clicking within the table itself.

The fields are the components of the raw data that are organized in the rows or columns. To access and change the location of the fields, click on the Pivot Table. The field list will appear on the right hand side of the window, and is highlighted in **yellow**. A funnel icon next to the category in the field list indicates that a filter is being used, one example of which is highlighted in **green**.

The filters can be accessed by clicking on the triangular buttons next to the table headers, highlighted above in **red**. Filters break down the data into more manageable and customizable parts – for example, with these tables, one might prefer to look at Formaldehyde byproducts in 2005 individually,

rather than among data for all Formaldehyde use from 2000 to 2010. Clicking on the filter brings up a checkbox list that indicates what sort of information is available to the viewer. It is up to the viewer to choose which aspects of the data should be displayed.

When changing the filters of a Pivot Table, one also changes the relationships shown on the graph. This should be kept in mind when interacting with the tables. If the tables and graphs are not responding to changes in data or filters, it is possible to refresh the data by clicking on the **Data** tab in the ribbon and selecting **Refresh All** (highlighted in purple in Figure 1).

Viewing the Pivot Charts

The Pivot Charts are manipulated similarly to the Pivot Tables. To access the field list and filters, simply click within the graph. The field list and filters will appear on the right hand side of the window in separate panes.

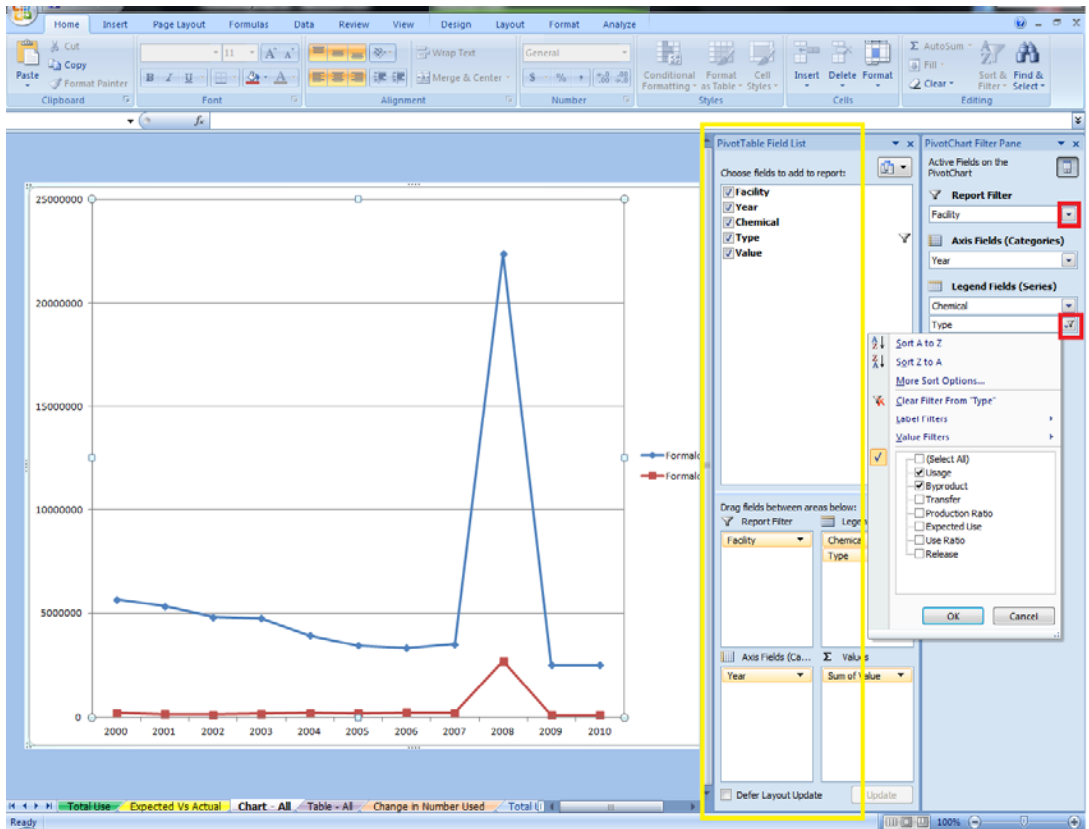


FIGURE 2. A TYPICAL VIEW OF THE PIVOT CHART. KEY COMPONENTS ARE HIGHLIGHTED.

Notes and Tips for Using These Pivot Tables

- When viewing **sum of value** data, it is possible to click on the particular cell in order to view all the data that was summed.

- Unless specified, all units of measurement are pounds.
- If the filter panes do not appear, they can be accessed by clicking on the table or chart, selecting the **Analyze** tab in the ribbon, and selecting **Field List** or **PivotChart/PivotTable Filter**.

Each file contains ready-made charts and tables of total use trends for all or individual chemicals, expected use, byproduct/use ratios, and numbers of Form S filers.

Appendix Three: Formaldehyde and Asthma

After providing a draft of this report to attendees of a TUR Advisory Council meeting, the American Chemistry Council Formaldehyde Panel wrote to OTA, objecting to the attempt “to link formaldehyde to asthma.” The Council stated that the “attempt to develop consumer guidance regarding formaldehyde, moreover, is ill-advised and without scientific justification. This is particularly true for composite wood products where emissions have been significantly reduced as a result of technological improvements.”

The OTA report is issued pursuant to statutory mandate. The mandate to all TUR program offices is to increase the information and awareness of all toxics users of their options for reducing the use of toxics. OTA’s appointed task is to help purchasers have the information they need to make good decisions on their own. The Office recommends decreased use of formaldehyde because it is a High Hazard Substance. The TUR approach is appropriate for all chemicals that can have adverse impacts. However, questions raised by the ACC encouraged us to review the evidence associating asthma with formaldehyde exposure. Provided below is a brief summary of the peer-reviewed literature about formaldehyde and asthma.

The Association of Occupational and Environmental Clinics’ (AOEC) Exposure Database lists formaldehyde as a generally accepted asthmagen.⁹⁸ The AOEC follows a strict protocol for evidence to determine which substances are asthmagens.⁹⁹ The Collaborative for Health and the Environment’s (CHE) Toxicant Disease Database lists the strength of evidence as “good.”¹⁰⁰ A comprehensive review of the peer-reviewed literature by Malo and Chan-Yeung lists an association between asthma and formaldehyde.¹⁰¹ This review confirms the earlier listing of formaldehyde as an asthmagen in a comprehensive listing of etiological agents.¹⁰² As early as 1939, there has been documentation of asthma in workers induced by formaldehyde exposure.¹⁰³ Cases of asthma due to formaldehyde exposure have been identified and supported by inhalation challenge testing not only among workers in manufacturing industries, but also those working in the health care industry.¹⁰⁴ The recent EPA IRIS Draft Toxicological Review of formaldehyde lists asthma as a noncancer health effect, citing studies

⁹⁸ <http://www.aoecdata.org/ExpCodeLookup.aspx>.

⁹⁹ http://www.aoec.org/content/Asthmagen_Protocol_10-25-08.pdf.

¹⁰⁰ <http://database.healthandenvironment.org/>.

¹⁰¹ Malo J-L, Chan-Yeung M. Appendix: Agents Causing Occupational Asthma with Key References. In: Bernstein LI, Chan-Yeung M, Malo J-L, Bernstein DI (eds). *Asthma in the Workplace*. 3rd Ed. New York: Taylor & Francis, 2006.

¹⁰² Chan-Yeung M, Malo J-D. 1994 Aetiological agents in occupational asthma. *Eur Respir J*;7:346-371. Series Occupational Asthma edited by C. Mapp.

¹⁰³ See: Vaughan WT. *The practice of allergy*. St Louis; Mosby, 1939:677.

¹⁰⁴ For example see: (1) Burge PS et al. Occupational asthma due to formaldehyde, *Thorax*. 1985;40:255-60; (2) Hendrick DJ and Lane DJ. Occupational formalin asthma, *Br Med J*. 1977;34:11-18; (3) Vandeplass O, et al. Persistent asthma following accidental exposure to formaldehyde, *Allergy*. 2004;59:115-116; (4) Kim CW, et al. Occupational asthma due to formaldehyde, *Yonsei Med J*. 2001;42:440-445; (5) Lemiére C, et al. Occupational asthma due to formaldehyde resin dust with and without reaction to formaldehyde gas, *Eur Respir J*. 1995;8:861-865.

showing increased asthma incidence, decreased pulmonary function, increase in respiratory symptoms, and increased allergic sensitization. The National Academy of Sciences panel review of the IRIS Toxicological Review did not question the association between formaldehyde and asthma. The American Conference of Governmental Industrial Hygienists labeled formaldehyde a sensitizer, based on its capacity to cause dermal and respiratory sensitization in 1987, and has not altered this designation.¹⁰⁵

The ACC objected to a contention that formaldehyde causes or exacerbates asthma at levels currently encountered in both residential and occupational settings, but OTA did not address the issue of levels of exposure. The ACC noted that studies on residential exposures and asthma have produced inconsistent results. This is true, but a recent broad meta-analysis on the question of formaldehyde and childhood asthma demonstrated a 17 percent increased odds of childhood asthma per 10- $\mu\text{g}/\text{m}^3$ increase in formaldehyde, and this statement:

“Subject to the limitations discussed above, the results of this systematic review suggest that there is a positive association between formaldehyde levels and childhood asthma. Taken in conjunction with a plausible biological mechanism, the results of this study provide important evidence regarding the potential causal link between formaldehyde and asthma in children. This is not to suggest that closure can be brought to this issue. Well-designed prospective epidemiologic studies are needed to shed additional light on this issue.”¹⁰⁶ Similar conclusions have been reached by additional researchers reviewing the recent body of evidence.¹⁰⁷ Also, the World Health Organization states that in children, “some case control and cross sectional studies have indicated a possible association between low formaldehyde exposure and asthma or sensitization to certain allergens.”¹⁰⁸

For specific levels, a report of the Lawrence Berkeley National Laboratory found: “From a review in 2003 of available data collected since 1990 [24] from convenience samples of U.S. homes (samples collected in homes convenient to researchers without any assurance that the resulting sample of homes is representative of all U.S. homes), about half had a formaldehyde concentration above 17 ppb and 10 percent of homes had a concentration greater than 37 ppb. Because a small fraction of homes had much higher concentrations, the estimated average concentration in a U.S. home was 55 ppb. In a survey of new homes in California (new homes tend to be more air tight and to have stronger formaldehyde sources), half of houses had a formaldehyde concentration greater than 31 ppb and 25 percent had a concentration greater than 60 ppb [25]. The outdoor concentrations of formaldehyde

¹⁰⁵ American Conference of Governmental Industrial Hygienists (ACGIH) 2012 Threshold Limit Values for Chemical Substances and Physical Agents. The TLV for formaldehyde (C 0.3 ppm), with SEN designation for sensitization, and A2 designation for cancer has been in place since 1987

¹⁰⁶ McGwin, et al, Formaldehyde exposure and asthma in children: A systematic review, *Environ Health Perspect.* 2010;118:313-317.

¹⁰⁷ See: Mendell MJ. Indoor residential chemical emissions as risk factors for respiratory and allergic effects in children: a review, *Indoor Air.* 2007;17:259–277.

¹⁰⁸ The World Health Organization (WHO) *Guidelines for Indoor Air Quality, Selected Pollutants - Formaldehyde*, p. 118.

ranged from 0.6 to 2 ppb. From these data, it is clear that formaldehyde concentrations in most homes exceed the repeated 8-hour guideline of 2 ppb established by the California Environmental Protection Agency (EPA) to prevent sensory irritation (and nasal effects) but that few homes are likely to have concentrations exceeding the higher guidelines established by other organizations to prevent sensory irritation.”¹⁰⁹

Although there are questions about formaldehyde’s effects, OTA’s research found widespread confirmation of an association with asthma. For example, Dr. Kenneth Rosenman, Chief of the Division of Occupational and Environmental Medicine at Michigan State University, recently wrote in *Clinical Pulmonary Medicine* that “Formaldehyde is both an irritant and sensitizer,” based on a review of “multiple reports on the respiratory effects of formaldehyde.” Although Dr. Rosenman wrote that “a limited number (of people) have positive bronchial challenge tests with sensitization,” he noted that “a majority of exposed individuals have irritation” and “Studies have shown enhanced sensitization to common environmental antigens in animals exposed to both formaldehyde and environmental antigens.”¹¹⁰

OTA’s recommendation to develop consumer guidance regarding formaldehyde therefore has substantial scientific justification. That emissions from composite wood products have been significantly reduced as a result of technological improvements is appropriate information to share, so that consumers will know about the availability of safer products. The more consumers learn about them, the more likely it is that the producers of those products will profit. In this way the economic goals of TURA are furthered, in addition to benefiting purchasers, workplaces, and the environment.

¹⁰⁹ <http://www.iagscience.lbl.gov/voc-sensory.html>.

¹¹⁰ “Cleaning Products-Related Asthma”, Volume 13, Number 4, July, 2006, p. 225.