# 2007

# Annual Report on Asthma Deaths Among Individuals Ages 2-34 and 45-54 in Michigan

An African American female in her fifties died from asthma after being short of breath for the day. As her family transported her to the ED, she lost consciousness at which time EMS was called. Her other medical conditions included obesity, hypertension, diabetes, and cardiovascular disease. She was an ex-smoker and worked as a nurse before she went on disability. The panel felt causal factors in this death were inadequate use of steroids, compliance issues with asthma triggers (cat), and a need for a referral to a specialist such as an allergist or a pulmonologist.

An African American male in his teens, who had asthma most of his life, died from an asthma attack in the fall. On the day of death, after walking back and forth to a religious service, he began having breathing problems and used his nebulizer. His brother reported to his mother, who was napping, that the deceased wasn't taking his medications anymore. The deceased became unresponsive and died in the ED. In the year prior to death, the deceased was seen in the ED four times and hospitalized four times for a breathing problem. The panel agreed that causal factors included inadequate use of steroids, no appreciation for the severity of the asthma, need for a referral to a specialist such as an allergist or a pulmonologist, lack of prescription of inhaled steroids in the ED, and lack of adequate adult supervision.

An African American male died after a more than two week hospital admission. He had an asthma exacerbation at home, and went to the ED where he was awake and alert. His other medical condition was hypertension. He smoked one pack of cigarettes per day, sometimes during his breathing treatments. The panel decided the causal factors in his death were patient compliance issues, inadequate diagnostic workup by physician, and delay in intubation at the hospital.

An African American preteen died from an asthma attack one evening after taking a bath. He went to his mother's bedroom and appeared to be out of breath. He turned on the nebulizer and a short while later his mother heard him yell "I'm about to die". His sister called to his mother and stated the deceased passed out in her arms. He was diagnosed with asthma as an infant. His other medical conditions were GERD, allergic rhinitis, and atopic dermatitis. He saw both an allergist and pulmonologist in the year prior to death. He was around cigarette smoke at home. The panel felt causal factors included second hand cigarette smoke exposure, bronchodilator overuse, need for an additional referral to a specialist for such a high risk patient, and lack of adequate adult supervision.

# 2007 Annual Report on Asthma Deaths Among Individuals in Michigan

A Joint Report

of the

Michigan State University
Department of Medicine
117 West Fee Hall
East Lansing, Michigan 48824-1315
(517) 353-1846

Kenneth D. Rosenman, MD, Professor of Medicine
Elizabeth Hanna, RN

and

The Michigan Department of Community Health
Bureau of Epidemiology
201 Townsend
P.O. Box 30195
Lansing, Michigan 48909
(517) 335-9080

Sarah Lyon-Callo, MS, Investigator
Elizabeth A. Wasilevich, PhD, MPH, Epidemiologist

September 22, 2010

The investigators of this project invite you to comment on this report and how you might use the information it provides by taking a brief online survey.
Please visit the following weblink to complete the survey:
http://www.surveymonkey.com/s.aspx?sm=Q8VjJ1IXbI4MMUFZkNhTAQ_3d_3d

# *Executive Summary*

This is the sixth Annual Report of Asthma Deaths in Michigan. Although death from asthma is relatively rare (~.01% of individuals with asthma), the circumstances surrounding these deaths are dramatic and are indicative of problems with asthma diagnosis and treatment among Michigan's 955,000 asthmatics. The deaths are particularly tragic because most are preventable. **Ninety-two percent (112 of 122) of the asthma deaths in Michigan with sufficient autopsy information to classify the type of asthma death were of the slow onset type and therefore preventable.** The majority of the deaths were among males (58%) and African Americans (58%). They were most likely to occur among residents of Wayne County (44%). The deaths typically occurred before the individual reached the hospital. Case summaries of the deaths are in Appendix I.

Over the past six years of investigation, the primary causal factor identified was the lack of patient adherence with good asthma management techniques, which includes regular use of inhaled corticosteroids rather than dependence on short acting β-agonists and elimination of asthma triggers such as cigarette smoke and pets. Major deficiencies were noted in asthma management by health care providers, including poor appreciation of the severity of the patient's condition and risk of future adverse events as indicated by a lack of timely referral to a specialist and inadequate prescription of inhaled corticosteroids. The low percentage of decedents with asthma action plans (only 20%) would suggest that more can be done by the health care system to provide information to patients to better manage their asthma. Particular recommendations were made for:

- Provider education on asthma risk and control, including the importance of the prescription of adequate levels of inhaled corticosteroids. This education should reach health care providers in all sectors including primary, urgent care and emergency departments.
- Public and caregiver/patient education that emphasizes the chronic and potentially fatal nature of asthma and the importance of the use of inhaled corticosteroids.
- Case Management for high-risk patients defined as an Emergency Department (ED) visit and/or a hospitalization for asthma and/or daily use of a short acting ß-agonist. This includes case management for children with asthma where lack of adequate parental supervision is a problem and adults with psychiatric problems.
- Pharmacy notification to health care providers for patients who repeatedly fill short acting β-agonist prescriptions and/or do not fill controller medication prescriptions for inhaled corticosteroids.
- Consider policies limiting the number of short acting β-agonist refills allowed without a new prescription or communication with the health care provider.
- Provision of more comprehensive asthma care in the ED setting that stops the cycle of repeated treatment of acute episodes. This should include prescription of inhaled corticosteroids at discharge and a system for assuring that patients see a primary care provider for follow-up.
- Referral to specialists for patients with a hospitalization or ED visit for asthma, who use short acting ß-agonists daily, or those with two or more oral corticosteroid bursts in a year.
- Need for health insurance including coverage of medication costs for adults with asthma (not an issue in children).

In depth investigations were undertaken for calendar year 2007 deaths occurring among children 2-18 years of age and adults 45-54 years of age. The 45-54 year old age group was chosen for in-depth investigation because the asthma mortality rates in this age group for African-Americans were two to nine times higher than Caucasians in recent years. In 2007, 10 of 22 deaths in this age

group were among African Americans. This report also includes results from in-depth investigation of child deaths for years 2002-2006, 19-34 year olds for years 2002-2005, and 45-54 year olds for 2006. Upon review, the expert panel felt that 16 out of 36 deaths among 45-54 year olds coded as an asthma death were primarily caused by something other than asthma. The Asthma Mortality Review project will continue for 2008 and 2009 deaths, for the 2-18 year old and 35 to 44 year old age groups.

# *Table of Contents*

# *Background*

Mortality from asthma in the United States had increased between 1980 through 1995[1,2]; although recent data suggest the asthma mortality rate has significantly decreased.[3] Over-use of β-agonists [4,5] and under-use of inhaled corticosteroids[6-8] have been associated with increased asthma mortality. Smoking, drinking, substance abuse[9] and family problems have been associated with increased asthma mortality, while the use of peak flow meters and a written asthma action plan have been associated with decreased asthma mortality.[10] Fatal asthma has also been associated with specific work exposures in reports for Michigan as well as throughout the world.[11]

Mortality is not evenly distributed across the population. Studies have shown high rates of asthma mortality among African Americans, low-income populations and populations with low educational levels.[12, 13] Reasons suggested for the racial disparity include differential access to care, exposure to environmental pollutants[14], and crowded conditions leading to increased exposure to allergens and infections.[15]

In response to a request for a proposal from the Centers for Disease Control and Prevention (CDC), the Michigan Department of Community Health (MDCH) in conjunction with Michigan State University (MSU) successfully competed to obtain funds to develop a rapid asthma death notification and investigation system for the State of Michigan. At the request of the CDC, this system was limited to investigations of asthma deaths among children and young adults ages 2-34 in the first four years of the project 2002-2005. CDC selected this age group because of the increased likelihood that deaths ascribed to asthma among 2-34 year olds were truly caused by asthma. For individuals younger than two years or older than 34 years the number of other medical conditions that may present with symptoms similar to asthma increases.

In 2006 and then again in 2007, in-depth investigations for asthma deaths among 2-18 year olds continued, while the focus for in-depth investigations of adult asthma deaths was changed to 45-54 year olds. A less intensive review of asthma deaths in all other age groups that began in 2006 was continued. The age group 45-54 had been selected because a marked disparity in African American deaths was noted in this age group in the years prior to 2006. A review of all other asthma deaths was added to address concerns that only 20% of the asthma deaths were being intensively investigated, and that important information was being overlooked by not reviewing the remaining 80% of asthma deaths. This report summarizes the first six years of investigations that cover asthma deaths occurring between January 1, 2002 and December 31, 2007.

Michigan's asthma mortality rate is slightly higher than the US in 2007 (12.7 versus 12.0 per million). However, the rate of asthma deaths for children 5-14 years in Michigan was significantly higher than the US rate (6.6 vs. 3.0 per million). Asthma mortality rates in Michigan have declined significantly between 2000 and 2007 for children 5-14 years, adults 65 years and older, and all age groups combined. Furthermore, dramatic racial disparities persist in Michigan's asthma mortality. The mortality rate for African Americans of all ages (31.4 per million) was over three times that of Caucasians (9.3 per million) in 2007. Asthma mortality rates for 5-14, 15-34, and 35-64 year age groups were over five times higher among African Americans compared to Caucasians. Rates of asthma mortality for Caucasians increased with age group however, rates for African Americans were not significantly different between age groups.[13]

From 1990 to 2007, there were a total of 2,968 deaths for Michigan residents where asthma was the underlying cause of death; including 485 deaths among the 2-34 year age group and 406 among the 45-54 year age group. The annual number of deaths in the 2-34 year age group has ranged from 15-39 deaths per year. Asthma deaths in the 2-34 year age group were almost equally distributed between males (260, 53.6%) and females (225, 46.4%). Two hundred seventy eight (57.3%) of the deaths were among African Americans and 202 (41.6%) were among Caucasians. From 1990-2007, there have been 14-38 deaths annually among the 45-54 year age group. For the 45-54 year olds, the distribution between men and women was 140 (34.5%) males and 266 (65.5%) females; and 165 (40.6%) for African American and 235 (57.9%) for Caucasians. Asthma deaths in Michigan were not evenly distributed throughout the year. The highest number of deaths is observed in the fall and winter for children and young adults. [13]

Asthma deaths are preventable. Successful disease management techniques are available to provide good control over asthma symptoms and a high quality of life. However, failure to maintain control over the disease results in a higher risk of mortality. Investigation of the reasons why people are not able to obtain and maintain good control allows us to identify preventable risk factors for asthma mortality and recommend ways to address these factors. Interventions that reduce these risk factors can prevent future deaths as well as improve management for all people with asthma.

# *Methods*

## *Notification of Asthma Deaths: Death Certificates*

Division of Health Statistics and Vital Records (DHSVR) staff at MDCH entered information from the death certificate into the master electronic file on a quarterly basis. Historically, they provided MDCH asthma staff with a transcript of information on all deaths with asthma as the underlying cause of death. The DHSVR transcript contained a limited set of data from the death certificate, including name, address, date of death, date of birth, sex, county of death, and county of residence. More recently, an electronic file of death certificate data is created from querying the master file and is sent to MDCH asthma staff. Using the transcript or electronic file information, MDCH asthma staff identified asthma deaths that met the study criteria:

- Asthma as underlying cause of death (ICD-10 codes J45 or J46)
- Michigan resident and death occurred in Michigan

Staff requested an administrative copy of the death certificates for deaths meeting these criteria.

## *Data Collection*

Upon receipt of the death certificate, a letter was sent to the next-of-kin listed to explain the project and to request an interview. This letter was sent to the next-of-kin of individuals 2-34 years who died from 2002-2005 and for individuals 2-18 and 45-54 years who died in 2006-2007. Interviews were conducted with the next-of-kin using a standardized questionnaire. All identified medical records from the year prior to death, pharmacy records, and, if applicable, emergency response records, medical examiner records and the autopsy report were requested. Since 2004, enrollment, health care, and pharmacy utilization records for decedents enrolled in Medicaid programs were acquired from the MDCH Data Warehouse as a means to identify medical records; this was especially helpful for the deaths where next-of-kin were not available for interview. After an interview with the next-of-kin was attempted or completed and after available records were reviewed, a one to two page summary of the circumstances surrounding the death for each of the individuals was prepared. In addition to the overall summary, a one-page summary was prepared for each of the medical records and autopsy reports reviewed.

For asthma deaths in 2006 and 2007 among those aged 19-44 and 55 or older, who did not have an in-depth investigation, medical records from the day of death, the medical examiner records and, if performed, the autopsy report were requested.

## *Expert Panel Review*

Two expert panels were convened: one for adults (reviewing deaths among individuals 19-34 years old in 2002-2005 and ages 45-54 in 2006-2007), and one for children (reviewing deaths for individuals aged 2-18 years). The advisory panels have included allergists, asthma educators, ED physicians, family practitioners, internists, nurses, pediatricians, pharmacists, pulmonologists, respiratory therapists, managed care organization medical directors, and social workers. Members of the two panels for the review of 2007 deaths are listed in Appendix II. Summaries of the data collected were shared with the appropriate advisory panels.

The Adult Mortality Review Panel and the Child Mortality Review Panel each met once to review completed investigations of the 2007 asthma deaths. The advisory panels reviewed the summary materials for individual deaths and were asked to list causal factors and follow-up preventive activities that were suggested by each death. These conclusions are described in the results section.

All medical records have been maintained in a confidential manner. Summaries shared with the advisory panels did not include personal identifiers for the individual who died, their next-of-kin, health care providers, health care systems or insurers. Both the MDCH Human Subjects Committee and the MSU Human Subjects Review Board reviewed this project. The MDCH Human Subjects Committee determined that this project was a surveillance activity and not human research. The MSU Human Subjects Review Board approved the project as human research. To provide further assurance of confidentiality this project was designated a Medical Research Project by the MDCH Chief Medical Executive under the provisions of MCL 333-2631-2635. This designation safeguards the confidential character of research studies conducted by MDCH and provides protection from release of the identifiable asthma mortality review materials for any purpose other than the research project.

Medical records for 2006 and 2007 asthma deaths in non-study age groups were reviewed by a physician who is board certified in internal and preventive medicine. He reviewed the death certificate, medical records from the day of death and an autopsy report when available. Based on this information, he reached a conclusion on whether the death was more likely than not secondary to asthma.

# *Results*

## *Information from Death Certificates*

During the six-year study period, there were a total of 804 deaths where asthma was the underlying cause for all ages, ranging from 120 to 150 per year (see Table 1). One hundred sixty (19.9%) of these deaths were among individuals age 2-34 years and 110 deaths (13.7%) were between the ages 45-54. The total number of deaths per year and age group are reported in Table 1.

**Table 1. Count of Asthma Deaths[1] Among Michigan Residents by Age Group with Shading Indicating Deaths Included in the In-Depth Asthma Mortality Review Panel (AMRP)[2]**

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2002-2007 |
|---|---|---|---|---|---|---|---|
| Asthma Deaths (≥2 years) | 150 | 132* | 134* | 135* | 120* | 131 | 802* |
| Children 2-18 years | 12 | 11 | 15* | 10 | 12 | 11 | 71* |
| Adults 19-34 years | 20 | 16 | 14* | 15* | 13 | 11 | 89* |
| Adults 35-44 years | 21 | 18 | 22 | 18 | 13* | 17 | 109* |
| Adults 45-54 years | 20 | 16 | 19* | 19* | 14 | 22 | 110* |
| Adults 55+ years | 77 | 71* | 64* | 73* | 68* | 70 | 423* |
| AMRP Study Deaths | 32 (21%) | 27 (20%) | 27† (20%) | 24† (18%) | 26 (22%) | 33 (25%) | 169† (21%) |

[1] Asthma as primary cause of death, ICD-10=J45 or J46
[2] Data Source: Michigan Death Statistical File, 2002-2007, MDCH
* Includes at least one Michigan resident who died out of state
† Excludes asthma deaths among Michigan residents who died out of state who were not included in the in-depth asthma mortality review

**The summary of data on asthma deaths among 19-34 year olds from 2001-2005 is presented in the 2005 Annual Report, which is available at www.oem.msu.edu and www.getasthmahelp.org.**

Table 2 summarizes the sociodemographic information obtained from the death certificates of the 172 asthma deaths ages 2-18 for all years, ages 19-34 in 2002-2005, and ages 45-54 in 2006-2007. This information includes those Michigan residents who died out of state.

**Table 2. Sociodemographic Characteristics of Asthma Deaths, Ages 2-18 (2002-2007), 19-34 (2002-2005), and 45-54 (2006-2007), Michigan Residents***

| | Children (2-18 years) 2002-2007 | Adults (19-34 years) 2002-2005 | Adults (45-54 years) 2006-2007 | Total 2002-2007 |
|---|---|---|---|---|
| **Number of Asthma Deaths** | 71 (41%) | 65 (38%) | 36 (21%) | 172 |
| **Average Age (years)** | 12.0 | 27.5 | 50.4 | - |
| **Sex** | | | | |
| Male | 61.0% | 58.5% | 52.8% | 58.0% |
| Female | 39.0% | 41.5% | 47.2% | 42.0% |
| **Race/Ethnicity** | | | | |
| Caucasian, Non-Hispanic | 17.0% | 47.6% | 63.9% | 38.4% |
| African American | 79.0% | 49.2% | 33.3% | 58.1% |
| Other Reported | 4.0% | 3.2% | 2.8% | 3.5% |
| **Education Completed** | | | | |
| College Graduate (4 year Degree) | 0% | 1.6%† | 11.1% | 2.9% |
| Some College | 1.4% | 29.7%† | 19.5% | 15.8% |
| High School Graduate | 2.8% | 46.8%† | 47.2% | 28.7% |
| Grades 6-11 | 53.5% | 20.3%† | 13.9% | 32.7% |
| Grades 5 and less | 42.3% | 1.6%† | 8.3% | 19.9% |
| **Place of Death (Pronounced)** | | | | |
| Hospital | 88.7% | 72.3% | 72.2% | 79.1% |
| Home | 11.3% | 24.6% | 27.8% | 19.8% |
| Vehicle | 0% | 3.1% | 0% | 1.1% |
| **Autopsied** | 80.3% | 80.0% | 47.2% | 73.3% |

*Includes information for Michigan residents who died out of state.
†One individual's education status was unknown and is not included

**Age**
The average age of children who died was 12.0 years (range: 2-18 years). Adults ages 45-54 had an average age of 50.4 (range 45-54).

**Gender**
Forty-three (61%) of the children who died were males and 28 (39%) were females (1.4 times as many males). In 2006 and 2007, there were nineteen (52.8%) males and seventeen females (47.2%) ages 45-54.

**Race/Ethnicity**
Fifty-six (79%) children who died were African American, while only twelve (17%) were Caucasian. The remaining three deaths were reported to be Mexican-American or Asian/Bangladeshi on the death certificate.

For adult's ages 45-54 in 2006 and 2007, twenty-three (63.9.6%) were Caucasian, twelve (33.3%) were African American and one was Hispanic.

The age group 45-54 was selected in 2006 for in depth review, because in recent years there had been a marked African American/Caucasian disparity. However, in 2007, 45.5 % of the deaths were among African Americans.

**Education**
Of the 36 adults ages 45-54 in 2006 and 2007 in the study, four (11.1%) had completed a four-year college degree, seven (19.5%) completed some college, seventeen (47.2%) completed high school, five (13.9%) completed grades 6 to 11, and three (8.3%) completed grade 5 or less.

**Place of Death**
The place of death listed in Table 2 reflects where the 172 people were pronounced dead, not where their fatal asthma attack occurred.

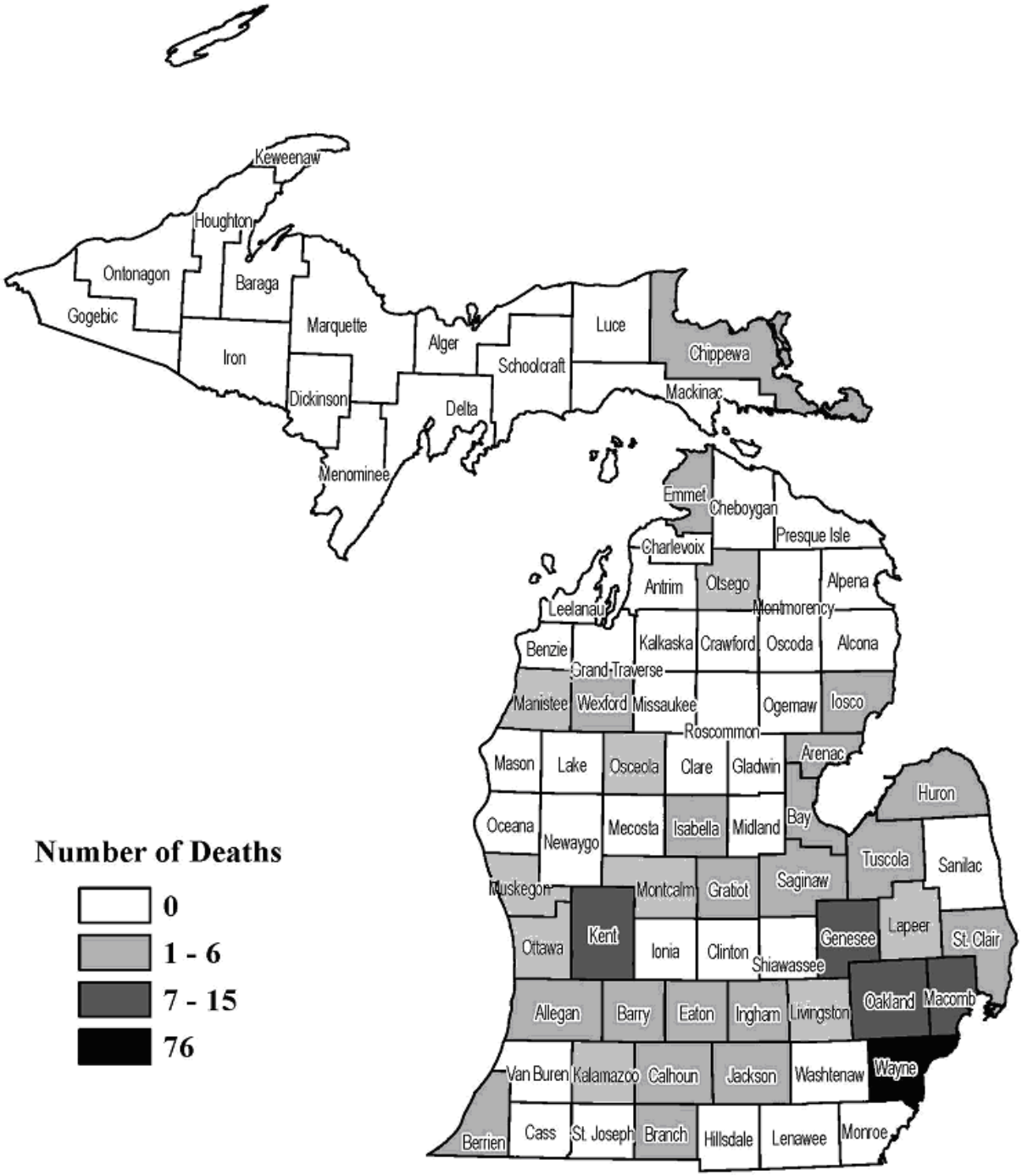
In 2006 and 2007, 26 adults ages 45-54 were pronounced dead in the hospital. Sixteen of the 26 hospital asthma deaths were non-responsive and in code status when the individual reached the hospital. Of the ten who were awake in the ED, nine died after being admitted to the hospital. Ten deaths listed home and 26 listed hospital as the "actual place of death".

Of the 66 children who were pronounced dead in a hospital, the death certificate for three of these children indicated that their home was the "actual place of death". Sixty-one children were non-responsive and in code status on arrival to the ED. Two were awake in the ED; one child died after being admitted to the hospital and the other died in transport to another hospital. The "actual place of death" listed on the death certificate for all 71 children were 63 hospital deaths and 8 home deaths.

**Autopsy**
Eighty percent of the children but only 47% of adults 45-54 years of age were autopsied. In comparison, 52 (80%) adults ages 19-34 in the years 2002-2005 were autopsied. The presence of mucus plugging has been used to distinguish asthma deaths with slow onset from sudden onset. Of the 126 deaths from 2002-2007 with autopsies, 112 (88.9%) showed mucus plugging in their bronchi, ten (7.9%) had empty/dry bronchi, for two (1.5%) individual the autopsy report did not address the airways and for two (1.5%) of the out-of-state deaths, the autopsies were not available. Using the presence of mucus plugging to characterize a death as slow onset versus the absence of mucus plugs as sudden onset of severe airway closure, 112 of 122 (92%) would be characterized as slow onset versus 10 of 122 (8.2%) as sudden onset.

**Location in State**
Wayne County was the most common residence of the deceased (76 deaths) (Figure 1). Four counties had between seven and 15 deaths (Genesee, Kent, Macomb, and Oakland). Twenty-nine counties had between one and six deaths (Allegan, Arenac, Barry, Bay, Berrien, Branch, Calhoun, Chippewa, Eaton, Emmet, Gratiot, Huron, Ingham, Iosco, Isabella, Jackson, Kalamazoo, Lapeer, Livingston, Manistee, Montcalm, Muskegon, Osceola, Otsego, Ottawa, Saginaw, Saint Clair, Tuscola, and Wexford).

**Figure 1. Asthma Study Deaths by County of Residence, Michigan, 2002-2007**



**Occupation/Industry**

Table 3 lists the most common occupations of adults ages 45-54 in 2006 and 2007 as homemaker/disabled. The most common industries listed on the death certificates were automotive, healthcare industry, manufacturing, and education.

**Table 3. Occupation and Industry of Adult Asthma Deaths Ages 45-54, Michigan, 2006-2007**

| Number | Occupation | Industry |
|---|---|---|
| 8 | At Home - Homemaker/disabled | |
| 28 | Assembler; Auto Repair; Avian Specialist; Bartender; Cosmetologist; Hammerman; Groundsman; Installer; Line Worker; Manager; Mechanic; Nurse; Nurse Aid; Office Manager; Owner of Business; Packager; Teacher; Waitress; Warehouse; Welder | Retail; Manufacturing; Automotive; Private Estate; Entrepreneur; Nursery; Technicolor; Restaurant; Healthcare; Government; Cosmetology; Agriculture; Education |

## *Day of Death Medical Record Information and Autopsy Results for Asthma Deaths Ages 2 and Older*

Review of medical records from the day of death and available autopsy reports found that 68% of all 2006 and 2007 deaths coded with asthma as the underlying cause of death seemed consistent with that determination. The percentage differed by age, ranging from 96% among 2-18 year olds to 53% among those 85 years or older (Table 4). Table 5 lists the conditions more likely to be the cause of death among the 32% of deaths that were indeterminate for asthma as the underlying cause of death.

The overall autopsy rate was 29%. The percentage autopsied differed by age, ranging from 96% among children to 0% among deaths of individuals age 75 years or older. Both autopsy reports and medical records from the day of death were important elements in the determination of cause of death. Autopsy reports helped to confirm whether an individual had asthma or a different medical condition that caused the death. The clinical information preceding the death was also important since a decedent could have asthma (identified through the medical records) without the death certificate indicating an acute asthma episode. The medical information available on the more elderly decedents was limited. Additional information might have changed the classification.

The less intensive review of asthma deaths in all other age groups proved useful in documenting inaccuracies in the recording and coding of cases of asthma as the underlying cause of death on death certificates and reinforced the importance of conducting more intensive investigations for children and young adults. The majority of the 2006-2007 deaths (68%) where asthma was considered the underlying cause of death were confirmed as an asthma death upon review of the medical records from the day of death and available autopsy results.

**Table 4. Review of Deaths Coded with Asthma as Cause of Death (10th ICD J45 or J46), Michigan 2006-2007**

| Age Group(Years) | Deaths | Autopsies | | Asthma Related Death Based on Medical Records and Autopsy Results | | |
|---|---|---|---|---|---|---|
| | # | # | % | | # | % |
| **2-18** | 23 | 22 | 96 | Yes | 22 | 96 |
| | | | | No | 1 | 4 |
| **19-34** | 24 | 20 | 83 | Yes | 21 | 87 |
| | | | | No | 3 | 13 |
| **35-44** | 29 | 15 | 52 | Yes | 21 | 72 |
| | | | | No | 6 | 21 |
| | | | | Indeterminate | 2 | 7 |
| **45-54** | 36 | 17 | 47 | Yes | 18 | 50 |
| | | | | No | 16 | 44 |
| | | | | Indeterminate | 2 | 6 |
| **55-64** | 31 | 4 | 13 | Yes | 26 | 84 |
| | | | | No | 5 | 16 |
| **65-74** | 28 | 1 | 4 | Yes | 19 | 68 |
| | | | | No | 8 | 28 |
| | | | | Indeterminate | 1 | 4 |
| **75-84** | 48 | 0 | -- | Yes | 30 | 63 |
| | | | | No | 18 | 37 |
| **85+** | 30 | 0 | -- | Yes | 16 | 53 |
| | | | | No | 14 | 47 |
| **Total** | 249 | 79 | 32 | Yes | 173 | 69 |
| | | | | No | 71 | 29 |
| | | | | Indeterminate | 5 | 2 |

**Table 5. More Likely Cause of Death Among Individuals Originally Coded as an Asthma Death, Michigan 2006-2007**

| Age Group (Years) | More Likely Cause of Death |
|---|---|
| **19-34** | Pneumonia<br>Pneumonia/Opiates<br>Goodpastures syndrome |
| **35-44** | Acute Pulmonary Edema<br>Cardiac Disease<br>Muscular Dystrophy<br>Cardiomegaly<br>Subarachnoid Bleed<br>COPD/Atrial Fibrillation/CHF |
| **45-54** | Congestive Heart Failure<br>Cardiac Disease (2)<br>Lupus Erythematosus<br>Pulmonary Hemorrhage<br>COPD<br>Cerebral Palsy/Seizure Disorder |
| **55-64** | Esophageal Cancer<br>Lung Cancer<br>Pneumonia (2)<br>Hepatic Failure |
| **65+** | Sudden Cardiac Death<br>Pulmonary Embolism<br>COPD/Dementia<br>Aspiration Pneumonia S/P Surgery<br>COPD (5)<br>Pneumonia (4)<br>COPD/Pneumonia<br>Congestive Heart Failure (3)<br>Cerebrovascular Accident<br>Cardiac Arrhythmia<br>Alzheimers<br>Dementia<br>Small Bowel Obstruction<br>Lung Cancer (2)<br>CHF/Acute Renal Failure<br>Colon Cancer<br>Alzheimer's/Atrial Fibrillation/Renal Failure<br>Ischemic Bowel<br>Renal Failure<br>COPD/Encephalopathy<br>Arrhythmia<br>Thrombophlebitis<br>CVA/Subarachnoid Bleed |

## *Asthma Death Review Process: In-Depth Investigations*

As noted previously, in-depth investigations occurred for 2002-2007 deaths among 2-18 year olds, 2002-2005 deaths among 19-34 year olds, and 2006-2007 deaths among 45-54 year olds. For findings from the in-depth investigations of deaths among 19-34 year olds, refer to reports published previously: http://oem.msu.edu/AnnualReports.aspx.

The average time between the death occurring and asthma death review staff notification was 108 days in 2002, 125 days in 2003, 197 days in 2004, 135 days in 2005, 119 days in 2006 and 112 days in 2007. The increase in time to notification in 2004 was secondary to equipment issues in the MDCH Division of Vital Statistics and Health Records.

Among the 33 asthma deaths ages 2-18 and 45-54 from 2007 in Michigan, the major difficulties in completing the next-of-kin interviews involved locating the next-of-kin and refusal from the next-of-kin. We were unable to locate five next-of-kin (two adult and three child deaths) and six next-of-kin refused to participate (all adult deaths).

At least partial medical records were obtained for all of the decedents in 2007 in the study age groups. The Michigan Medicaid utilization data allowed for the identification of additional medical records for the deceased who had Medicaid whether or not they had a next-of-kin interview. Table 6 provides the frequency of available information for next of kin interviews.

**Table 6. Asthma Mortality Investigations, Ages 2-18 (2002-2007), 19-34 (2002-2005) and 45-54 (2006-2007), Michigan**

| | Children (2002-2007) 2-18 | Adults (2002-2005) 19-34 | Adults (2006-2007) 45-54 |
|---|---|---|---|
| **Deaths Eligible for Review** | 70 | 63 | 36 |
| **Unable to Locate Next-of-Kin** | 17 (24.3%) | 7 (11.1%) | 3 (8.3%) |
| **Next-of-Kin Refused Interview** | 8 (11.4%) | 6 (9.5%) | 8 (22.2%) |
| **Interviews Completed** | 45 (64.3%) | 50 (79.4%) | 25 (69.4%) |

## *Information from Data Collection*

The following discussion includes all children from 2002-2007 and adults ages 45-54 in 2006-2007 (see earlier reports for details on 2002-2005 investigations for deaths occurring among 19-34 year olds). The denominators for the different risk factors listed below vary due to the availability of records or whether all of the next-of-kin interviews were completed. After each percentage is the number with a positive response and the denominator for that factor. Table 7 summarizes the risk factors for all age groups studied for the duration of the Asthma Mortality Review Project.

**Insurance**
95% (63 of 66) of children and 97% (33 of 34) of adults ages 45-54 (where insurance status was known) had medical insurance, as determined from medical record review and next-of-kin interviews.

83% (58 of 70) of children and 58% (21 of 36) of adults 45-54 years old were enrolled in Medicaid at some time during their life, as determined from querying Medicaid enrollment files. At the time of their death, 73% (51 of 70) of children and 39% (14 of 36) of adults ages 45-54 were enrolled in Medicaid.

Among the 100 individuals with medical insurance where information about co-payment was known, 88% (44 of 50) had co-pays of $10 or less, one had a 10% co-pay, three had $15-20 co-pay, one had a $2500 deductable and one had an 80% co-pay. Thirty-three percent (4 of 12) of the children's next-of-kin or health care providers mentioned that co-pays or cost of referrals for specialists and testing interfered with the patient's management (one had a 80% co-pay, one had a $10 co-payment, and two co-pays were unknown).

**Co-morbidities**
Eighty-eight percent (29 of 33) of adults ages 45-54 and 39% (24 of 62) of children were reported to have one or more co-morbid medical conditions, such as Down's Syndrome, Crohn's disease, diabetes, hypertension, cerebral palsy, spinal muscular atrophy, scoliosis, autism, hypoxic encephalopathy, mental retardation or seizures which complicated their asthma management. Another five had a psychiatric condition, such as major depression, bipolar disease or schizophrenia; this accounted for 4% (2 of 55) of children and 23% (7 of 31) of adults ages 45-54.

**Substance Abuse**
Fifty-seven of 70 (81%) children and 17 of 36 (47%) of adults were autopsied. Of the available toxicology reports, four adults and two children tested positive for illicit drug use at autopsy. One adult tested positive for cocaine and alcohol, another was positive for marijuana and alcohol, the third for Methadone and alcohol and the fourth for only marijuana. Both children tested positive for marijuana. Substance abuse issues were mentioned by the next-of-kin or a health care provider in 35% of the adult deaths (11 of 31), and 2% of the child deaths (1 of 54). Three adults and one child who were positive for illicit drugs also had their next-of-kin mention substance abuse during the interview.

**Family Dysfunction**
There appeared to be a lack of parental supervision or family dysfunction that interfered with asthma management in 25% (10 of 40) of the child deaths. Examples of family dysfunction include: psychological disorder, alcohol/drug abuse, incarceration among caregiver/parents or caregiver/parents not around, parental dysfunction noted in the medical record, and involvement of child protective services. In addition to these marked forms of parental dysfunction, it was felt by the panel that 26% of the children should have had more adult supervision when medications were administered.

**Triggers**
Fifty-two percent (16 of 31) of 45-54 years decedents were current cigarette smokers. This proportion of current smokers was 2.3 times greater than the percentage of smokers in the general population of adults in this age group, 22.6% (95% CI: 20.3, 25.2)[16]. Of the adults ages 45-54 who did not smoke, 40% were exposed to secondhand smoke at home. Among adults with asthma in

the general population, 22.4% (95% CI: 19.3, 25.9) lived where there was smoking inside the home[16].

Forty-three percent (21 of 49) of the deceased children lived with a cigarette smoker and 10% (5 of 50) of the deceased children smoked. Among children with asthma in the general population, 20.4% (95% CI: 13.7-29.4) lived where there was smoking inside the home – two times less than among those who died[16].

Fifty-two percent (24 of 46) of children and 62% (13 of 21) of adults ages 45-54 had dogs and/or cats living in their homes at the time of their death. This was similar to the general population of people with asthma in Michigan, where 60.6% (95% CI: 52.7-68.0) of children and 62.4% (95% CI: 58.7-66.0) of adults reported living with a furry or feathered pet [16].

**Routine Asthma Management**

About 72% (41 of 57) of children and 78% (25 of 32) of adults were taking an inhaled and/or oral corticosteroid. Of those who were taking corticosteroids, about 40% (23 of 57) of children and 34% (11 of 32) of adults were taking only inhaled corticosteroids; and 9% (5 of 57) of children and 19% (6 of 32) of adults were taking only oral corticosteroids. Twenty-three percent (13 of 57) of children and 25% (8 of 32) of adults were taking both inhaled and oral corticosteroids.

Other aspects of lifetime medical care included:

- ***Allergist Care:*** 32% (6 of 19) of adults ages 45-54 and 60% (26 of 43) of children had ever seen an allergist during their lifetime.
- ***Pulmonologist Care:*** 65% (17 of 26) of adults ages 45-54 and 51% (23 of 45) of children had ever seen a pulmonologist.
- ***Combined Specialist Care:*** 42% (5 of 12) of adults ages 45-54 and 37% (15 of 41) of children had seen both an allergist and pulmonologist; 37% (7 of 19) of adults ages 45-54 and 29% (12 of 41) of children had seen neither an allergist nor a pulmonologist during their lifetime. Seventy-three percent of adults ages 45-54 and 34% of children had seen either a pulmonologist or an allergist. National guidelines contain recommendations for when patients should be seen by a specialist [17]; the majority of these patients met one of the criteria in the year prior to their death.
- ***Pulmonary Function Testing:*** 53% of children and 65% of adults 45-54 years old had ever had pulmonary function testing that included at least spirometry during their lifetime. It is recommended that spirometry be used to aid in the management of asthma after treatment is initiated and symptoms have stabilized to document "normal" airway function, and at least every 1 to 2 years to assess the maintenance of airway function[17].
- ***Peak Flow Meter:*** 70% (33 of 47) of children and 52% (11 of 21) of adults ages 45-54 owned a peak flow meter (only seventeen of the children and two of the adults with a peak flow meter used it regularly per next-of-kin reporting).
- ***Asthma Action Plan:*** One of the adults ages 45-54 and 34% (16 of 47) of the children had an asthma management plan. The frequency of having been given an asthma action plan in the general population of people with asthma in Michigan was about the same for children (40.2%, 95% CI: 33.6, 47.3) and notably higher for adults (27.0%, 95% CI: 23.7, 30.6) [16].

**Urgent Asthma Management**

Thirty-nine percent (9 of 23) of adults and 27% (13 of 48) of children had a history of prior intubation in their lifetime. Eighty-five percent (45 of 53) of children and 78% (18 of 23) of adults ages 45-54 had been previously admitted to the hospital for respiratory problems, including 59% and 54%, respectively, in the year prior to death. This was significantly higher than similar estimates for the general population of people with asthma in Michigan; only 3.0% (95% CI: 1.8, 5.0) of children with asthma and 3.6% (95% CI: 2.7, 4.9) of adults with asthma reported being hospitalized for asthma in the last year [16].

Eighty-eight percent (45 of 51) of children and 93% (25 of 27) of adults had an ED visit for respiratory problems in their lifetime, including 74% and 83%, respectively, in the year prior to death. This was significantly higher than that for the general population of people with asthma in Michigan: 17.3% (95% CI: 12.1, 24.2) of children and 12.4% (95% CI: 10.2, 15.0) of adults reported having had an ED visit in the last year [16].

**Obesity**

At the time of their death, 62% (21 of 34) of adults were considered obese, with a body mass index (BMI) of 30 or greater. One of the adults was considered overweight (BMI of 25 to 29). The prevalence of obesity among the deceased adults was 2.0 times higher than that for the general adult population of Michigan. According to the 2007 Michigan Behavioral Risk Factor Survey, 30.4% (95% CI 27.8, 33.1) of 45-54 year olds are obese[18].

The percentage of children considered obese (BMI-for-age of 95$^{th}$ percentile or greater) at the time of death was higher than expected compared to national data. Twenty-eight percent (19 of 68) of the children had a BMI that was at the 95$^{th}$ percentile or greater for their age, 22% (15 of 68) were in the 85$^{th}$ to 94$^{th}$ percentile and 50% (34 of 68) were less than the 85$^{th}$ percentile. The BMI of two children was unknown. Weight status data for the general population of Michigan children is not available. Nineteen percent of U.S. children 6-11 years and 17% of U.S. children 12-19 years have a BMI at the 95$^{th}$ percentile or greater for their age[19].

Weight status among the deceased children and adults did not vary significantly by race. Among African American children, 31% (17/55) had a BMI that was at the 95$^{th}$ percentile or greater versus 36% (4 of 11) of Caucasian children. Among African American adults, 64% (7 of 11) had a BMI of 30 or greater versus 59% (13 of 22) of Caucasian adults.

**Table 7. Asthma Management Characteristics, Ages 2-18 (2002-2007), 19-34 (2002-2005), and 45-54 (2006-2007), Michigan**

| | Children 2-18 (2002-2007) | Adults 19-34 (2002-2005) | Adults 45-54 (2006-2007) | Total |
|---|---|---|---|---|
| **Insurance Status** | | | | |
| Deceased Had Some Form of Health Insurance | 95% | 79% | 97% | 90% |
| Insurance Had Co-Pays | 27% | 56% | 46% | 41% |
| Co-pay Mentioned as Reason for Not Filling Medication, Seeing Specialist, or Getting Tests | 10% | 6% | 24% | 11% |
| **Deceased Had Co-Morbid Condition** | 39% | 45% | 88% | 52% |
| **Deceased Had Psychological Illness** | 4% | 19% | 29% | 14% |
| **Significant Substance Abuse Noted** | 2% | 29% | 35% | 20% |
| **Family Dysfunction** | 25% | 12% | 5% | 16% |
| **Exposure to Triggers** | | | | |
| Current Smoker | 10% | 43% | 52% | 33% |
| Smoker in the Home | 43% | 57% | 57% | 51% |
| Pets in the Home | 52% | 60% | 62% | 57% |
| **Routine Asthma Management** | | | | |
| Taking Only Inhaled Corticosteroids | 40% | 35% | 34% | 37% |
| Taking Only Oral Corticosteroids | 9% | 14% | 19% | 13% |
| Taking Both Inhaled and Oral Corticosteroids | 23% | 14% | 25% | 20% |
| No Corticosteroids | 28% | 37% | 22% | 30% |
| Seen by Specialist during lifetime | 75% | 65% | 73% | 71% |
| Seen by Allergist | 60% | 52% | 32% | 52% |
| Seen by Pulmonologist | 51% | 44% | 65% | 53% |
| Ever Had Pulmonary Function Testing | 53% | 52% | 65% | 55% |
| Had a Peak Flow Meter | 70% | 56% | 52% | 61% |
| Regularly Used Peak Flow Meter | 55% | 8% | 11% | 28% |
| Had a Nebulizer | 85% | 71% | 80% | 79% |
| Asthma Management Plan during lifetime | 34% | 9% | 6% | 20% |
| **Urgent Asthma Management** | | | | |
| Prior History of Intubation | 27% | 34% | 39% | 32% |
| Previously Hospitalized for Asthma in Lifetime | 85% | 64% | 78% | 75% |
| Hospitalized in Year Prior to Death | 59% | 45% | 54% | 52% |
| Previous ED Visits for Asthma in Lifetime | 88% | 88% | 93% | 89% |
| ED Visit in Year Prior to Death | 74% | 68% | 83% | 74% |
| Average Number (range) of Asthma ED Visits In Year Prior to Death | 2.8 (1-20) | 7.3 (1-52) | 2.2 (1-10) | 2.14 (1-52) |

| **Weight** | | | | |
|---|---|---|---|---|
| ***Children 2-18*** | | ***Adults*** | ***19-34*** | ***45-54*** |
| $\geq$ 95 percentile | 28% | Obese (BMI 30+) | 47% | 62% |
| $\geq$ 85-94$^{th}$ percentile | 22% | Overweight (BMI 25-29) | 24% | 3% |
| < 85$^{th}$ percentile | 50% | Not Overweight (BMI<25) | 29% | 35% |

## *Asthma Death Review Findings: Causal Factors*

Causal factors may include: patient-related factors (such as adherence to prescribed medication regimen, trigger avoidance, and the need for patient education); physician-related factors (such as the need for education or changes in practice behavior); and system-related factors (such as lack of health care, need for changes in health care provision, or asthma management provisions in foster care systems). Table 8 provides causal factors identified by the expert panel for the 36 adult asthma deaths reviewed in 2006-2007. Table 9 provides causal factors for the 70 child deaths reviewed from 2002-2007.

**Adults:**
The most frequent causal factors for adult deaths 45-54 years of age cited by the panel were:

1. *Compliance issues, such as using prescribed corticosteroids and following advice to eliminate asthma triggers.*

2. *The need for a specialist referral for high-risk patients.*

3. *The inadequate prescription of corticosteroids by health care providers.*

4. *Lack of regular medical care with a primary care physician, and a lack of health insurance.*

**Children:**
The most frequent causal factors for asthma deaths in children were:

1. *Inadequate use of corticosteroids and over-use of short acting β-agonists, including the improper use of a home nebulizer.*

2. *Compliance issues such as lack of elimination of triggers.*

3. *The need for specialist referral for high-risk patients.*

4. *The inadequate prescription of corticosteroids by health care providers.*

5. *Lack of adequate adult supervision and regular maintenance health care visits.*

**Table 8. Causal Factors for Asthma Mortality, Ages 45-54, Michigan, 2006-2007 (n=36)**

| Factor | Number of Deaths* |
|---|---|
| **Patient-Related Factors** | |
| Inadequate Use of Corticosteroids/Over-use of Short Acting β-agonists | 14 |
| Compliance | 10 |
| Drug Abuse | 2 |
| Depression/Psychiatric Disorder | 4 |
| Obesity | 2 |
| Lack of Knowledge about Allergen Triggers | 3 |
| **Physician-Related Factors** | |
| Needed Referral or Inadequate Diagnosis for High-Risk Patients | 18 |
| Inadequate Prescription of Corticosteroids | 9 |
| **System-Related Factors** | |
| Lack of Regular Medical Care | 7 |
| Lack of Health Insurance | 6 |

*Multiple causal factors are possible for each of the 18 deaths that the expert review panel determined was truly caused by an asthma attack; the expert review panel did not consider sixteen deaths to be caused by asthma and that there was enough information to assess causal factors; for 2 deaths there was insufficient information.

**Table 9. Causal Factors for Asthma Mortality, Ages 2-18, Michigan, 2002-2007 (n=70)**

| Causal Factor | Number of Deaths* |
|---|---|
| **Patient–Related Factors** | |
| Inadequate use of Corticosteroids/Over-use of Short Acting β-agonists | 30 |
| Compliance: Trigger Avoidance; Pets; Referral to Specialist | 27 |
| Co-Morbid Conditions | 5 |
| Inadequate Appreciation of Severity | 3 |
| Aspirin Sensitivity | 1 |
| **Physician-Related Factors** | |
| Needed Referral or Inadequate Diagnosis for High-Risk Patients | 23 |
| Inadequate Prescription of Corticosteroids/Over Prescription Bronchodilator | 14 |
| Need to have Nurse Visit Home | 1 |
| **System-Related Factors** | |
| Lack of Adequate Adult Supervision | 18 |
| No Regular Maintenance Health Care Visits | 10 |
| Repeated Refill of Bronchodilators | 5 |
| Psycho Social and Psychiatric Issues | 4 |
| Lack of Knowledge of CPR by Family Members | 2 |
| Delay on EMS Response | 1 |
| Lack of Insurance to Cover Medication | 1 |

*Multiple causal factors are possible for each of the 70 deaths.

## *Other Issues Raised During the Death Reviews*

We expected to find more deaths related to certain risk factors. There were only three asthma deaths that the panel felt were related to care received for the fatal attack in the Emergency Department. There were seven asthma deaths where illegal drug usage may have been a factor in compliance but none in which it was related to the immediate cause of death. Although peak flows meters were available but rarely used by the deceased, the lack of regular use of peak flow meters was felt by both the child and adult advisory panels to be symptomatic of more important health care management deficiencies rather than a direct causal factor. Both the adult and child advisory panels felt that it was more important to put emphasis on steroid use rather than peak flow usage.

The expert panels questioned whether the death was caused by asthma in sixteen of the 36 adult cases with in-depth reviews in 2006-2007. Some of this difference has to do with whether medical examiners are provided sufficient clinical information that would allow them to accurately record the cause of death. The expert panels had medical records from the year prior to death. Additionally, panel members questioned whether, under certain circumstances, the federal algorithm developed by the National Center for Health Statistics that is used to code the cause of death will code a death as asthma when asthma is only listed on the death certificate as "other significant conditions contributing to the death" but not in the causal chain of events/conditions.

A large percentage of the adults and children who died were obese, 62% and 28% respectively. These percentages are greater than those found in the general population, 30.4% for 45-54 year-old adults[18] and 16% in children[19] There has been some disagreement in the medical literature over whether obesity is a consequence of decreased physical activity among people with asthma and not a risk factor for asthma[20] and/or whether the increase in asthma symptoms reported by obese individuals is truly asthma or is a consequence of misdiagnosis of asthma among obese individuals[21]. Mechanisms for obesity that adversely affect respiratory function have been described but further longitudinal studies are needed to better understand the cause of the association[22].

## *Asthma Death Review Panel Recommendations*

**Adults**

The major issue for adult deaths in the 45-54 year old group was the need to ensure that cause of death was more accurately recorded on the death certificate. The fact that the autopsy rate was 47% in adults 45-54 years old in comparison to 80% among younger adults ages 19-34 contributed to the difficulty in ensuring an accurate cause of death.

Suggested interventions involved education on the prescription and use of corticosteroids for both health care providers and patients (see Table 10) and education of health care providers on the need to refer high-risk patients to specialists.

The need for case managers for high-risk patients was also recognized. Active case management for individuals with repeated hospitalizations and emergency department visits is needed. A mechanism to provide case management is needed, including home visits even for patients who are not compliant with physician visits. Case management currently provided to patients generally involves patients who keep appointments for routine health care visits and is not provided to less compliant patients.

*A system level change suggested by the expert panels was to include a mechanism to prompt* health care providers to reassess the medication regime. An example of a system level change would be pharmacy notification to health care providers of patients who frequently fill β-agonist prescriptions, or restricting the patient from refilling β-agonist prescriptions after a certain number of refills have been given. The overuse of inhaled β-agonists was intertwined with the under-use of inhaled corticosteroids; it should be noted that we were not able to separate these closely related factors.

Education to improve patient adherence to regular use of inhaled steroids and eliminating triggers was a high priority. The low percentage of deceased asthmatics with written asthma management plans supported the review panels' conclusion that patient education and coordination of care are areas where significant improvement could be made.

**Table 10. Recommended Interventions for Asthma Mortality for Adults Ages 45-54, Michigan, 2006-2007 (n=36)**

| Recommendation | Number of Deaths* |
|---|---|
| **Educate Health Care Providers** | |
| Need to Refer High-Risk Patients to Specialists | 14 |
| Need for Inhaled Corticosteroids | 9 |
| Need for Pulmonary Function Tests | 6 |
| **Educate Patients** | |
| General Asthma Education and Need for Regular Care | 14 |
| Need to Use Corticosteroids | 11 |
| Smoking Cessation | 2 |
| Substance Abuse | 1 |
| **System Level Changes** | |
| Pharmacy Notification of Excessive Short Acting β-agonist Use/Under Use of Inhaled Corticosteroids | 5 |
| Need for Case Management | 11 |
| Improve Insurance Coverage for Asthma Medication | 4 |
| **Medical Examiners** | |
| Develop Clear Criteria for Identifying Asthma Deaths | 14 |

*Multiple interventions are possible for each of the 36 deaths.

**Children**

Like adults, education on the prescription and use of corticosteroids for both health care providers and patients was the highest priority (see Table 11). Some mechanism, such as notification of health care providers by pharmacies to monitor or restrict the refilling of β-agonist prescriptions to reduce β-agonist over-use was favored. The overuse of inhaled β-agonists was intertwined with the under use of inhaled corticosteroids and we did not attempt to separate these closely related factors. Timely referral to a specialist was also indicated. Interventions specific to children included: setting up a focus group of teenagers with asthma to better understand how to conduct asthma education in this age group; attention to foster care environment (i.e. presence of asthma triggers); and a school-based asthma plan. Insurance issues, either coverage or co-pays, were not noted to be a significant problem with children.

**Table 11. Recommended Interventions for Asthma Mortality for Children Ages 2-18, Michigan, 2002-2007 (n=70)**

| Recommendation | Number of Deaths* |
|---|---|
| **Educate Health Care Providers** | |
| Referrals for High-Risk Patients | 15 |
| Need for Inhaled Corticosteroids, Include ED Doctors | 14 |
| Limitation of Refills for Bronchodilators Without a Physician Visit or Active Approval | 4 |
| Need for Pulmonary Function Test | 3 |
| **Educate Patients** | |
| Education of Patients/Family, Possibly Focus Groups for Teenagers | 38 |
| Dangers of Aspirin Sensitivity | 1 |
| **System Level Changes** | |
| Case Manager for High-Risk Cases | 26 |
| Pharmacy Notification of Excessive Bronchodilator Use or if Long Term Controls Prescription Not Filled | 14 |
| School Based Asthma Program | 10 |
| Child Protective Services Including Attention Needed for Foster Care Environment | 6 |
| Inadequate Emergency Medical Response | 2 |
| Development and Dissemination of Generic Action Plan | 1 |
| Better Labeling of Aspirin Products | 1 |
| Transportation Costs in Rural Area for High-Risk Cases | 1 |
| Improve Accessibility to Children's Special Health Care Program | 1 |
| Resolve Multiple Formulary Plans | 1 |
| CPR Training of Family Members, Part of Hospital Discharge Planning | 1 |
| **Medical Examiners** | |
| Develop Clear Criteria for Identifying Asthma Deaths | 2 |

*Multiple interventions are possible for each of the 70 deaths.

# *Discussion*

Asthma is a chronic, but manageable condition. This project is based on the premise that most, if not all, asthma deaths are preventable with appropriate asthma management.

The 805 asthma deaths from 2002 through 2007 represent only a small percentage (0.16%) of all 518,334 deaths that occurred in Michigan during this same 6-year period. However, asthma is a treatable condition and each asthma death is a tragedy that could have been prevented, particularly the 163 deaths that occurred to children and young adults less than 35 years. The problems identified among individuals dying from asthma are the same problems that have been associated with increased morbidity, increased impairment with lost work and school days and increased health care costs among the estimated 955,000 Michigan residents with asthma.

The primary causal factor identified in this investigation for adults in both age groups and children was a lack of patient compliance with good asthma management: this includes regular use of inhaled corticosteroids rather than dependence on β-agonists and elimination of asthma triggers such as cigarette smoke and pets. Major deficiencies noted in health care providers' management of their patients with asthma include a lack of appreciation of the severity of the patient's condition with no referral to a specialist and inadequate prescription of inhaled corticosteroids. The small percentage of people with asthma with an asthma management plan (only 19%) suggests the health care system could do more to provide patients information to better manage their asthma. Particular recommendations were made for:

- Emphasis on the chronic and potentially severe nature of asthma and the importance of prescription of inhaled corticosteroids by health care providers in all sectors (primary and urgent care) and their use among people with asthma.
- Case Management for high-risk patients (patients with an ED visit and/or a hospitalization for asthma and/or daily use of a short acting β-agonist). This includes case management for children with asthma where lack of adequate parental supervision is a problem and adults with psychiatric problems.
- Pharmacy notification to health care providers for patients who repeatedly fill β-agonist prescriptions and/or do not fill controller medication prescriptions for inhaled corticosteroids.
- Consider policies limiting the number of short acting β-agonist refills allowed without a new prescription or communication with the health care provider.
- Provision of more comprehensive asthma care in the ED setting that stops the cycle of repeated treatment of acute episodes. This should include prescription of inhaled corticosteroids at discharge and a system for connecting patients with a primary care provider for follow-up.
- Public and patient education that emphasizes the chronic and potentially fatal nature of asthma and the importance of the use of inhaled corticosteroids.
- Provider education on asthma risk and control, including the importance of the prescription of adequate levels of inhaled corticosteroids. This education should reach health care providers in all sectors including primary, urgent care and emergency departments.
- Referral to specialists for patients with a hospitalization or ED visit for asthma or who use short acting ß-agonists daily.
- Need for health insurance including coverage of medication costs for adults with asthma (not a problem in children).

It has been suggested by some researchers that asthma deaths can be divided into two types: 1) slow onset, late arrival for care and poor use of corticosteroids because of psychological, social and cultural factors; and 2) sudden onset of severe airway closure[23]. The pathology on autopsy in the first type of death shows abundant sticky mucus plugging in the airways and in the second there are empty/dry airways suggesting sudden airway closure by a neural mechanism. The second type of asthma death, sudden onset, is more difficult to prevent. One hundred twenty four Michigan asthma deaths had an autopsy from 2002-2007 where in-depth investigations were performed. For two of the 124 autopsies, an onset type could not be determined. **Ninety-two percent (112/122) were the slow onset type and therefore were preventable.**

Our findings are discussed in relation to the National Heart, Lung, and Blood Institute guidelines which emphasize the importance of inhaled corticosteroids, increased use of spirometry as an objective test for both diagnosis and management of asthma patients, and the need for referral to a specialist[17].

## *Actions Taken*

Annual reports were distributed to asthma stakeholders and policy makers across Michigan, including members of the Michigan Asthma Advisory Committee and its subcommittees; contacts at all local asthma coalitions; all local public health officers in Michigan; and all managed care plan medical directors and quality improvement directors in Michigan. Copies have also been sent to the Michigan State Library; Michigan State Medical Society; Michigan College of Emergency Physicians; and the Michigan Nurses' Association. The report was distributed widely within the state health agency including to the MDCH Director; directors of Chronic Disease, Maternal Child Health, and Health Disparity Reduction programs. The report has also been distributed to health care providers who requested a copy, Centers for Disease Control and Prevention asthma staff, and asthma contacts in all 50 states.

The findings have been presented to staff in the Michigan Department of Community Health's Public Health Administration; to the Michigan Asthma Advisory Committee and its Quality Improvement in Asthma Care Work Group, including members for MDCH Medical Services Administration, to the Michigan Child Death Review State Advisory Board, MDCH Medicaid Clinical Advisory Board, and through selected presentations to local asthma coalitions, physicians and allied health workers through grand rounds, conferences, and national meetings. Data were presented to the Detroit Asthma Mortality Summit held in January 2009. Data have also been presented to the Medical Directors and Quality Improvement Directors of the Michigan Association of Health Plans, Implementation Committee of the Michigan Quality Improvement Consortium, and the Michigan College of Emergency Physicians. Data were also presented to the organization representing Medical Examiners to discuss criteria for recording a death as being secondary to asthma.

These findings have also had a national audience. The methods and results were presented per request to CDC Asthma Control Program staff and other state asthma programs nationally via teleconference as well as published in a national journal[24]. Findings on nebulizer use were presented at the Annual Meeting of the College of Chest Physicians[25] and picked up by national media. Findings on a secondhand smoke-related death were published in a medical journal[26] and were also picked up by the national media.

A number of actions have been taken based on these findings:

- The findings and methods have contributed to development of an asthma protocol for Child Death Review that has been shared with all Child Death Review Panels in the state.

- A physician education activity, including online CME course (www.oem.msu.edu), has been developed from the blinded case studies used for panel review.

- The Michigan Asthma Advisory Committee (MAAC) used the findings and recommendations in past annual reports to help shape the revision of the state's strategic plan for addressing asthma.

- The Michigan Medicaid Drug Utilization Review Board used these recommendations to support the implementation of pharmacy utilization reporting and develop educational materials to the providers of Medicaid patients who are filling many prescriptions for short-acting β-agonists without filling any prescriptions for long term controllers.

- The MAAC's Quality Improvement in Asthma Care work group developed of a set of standardized discharge instructions for asthma patients treated in the Emergency Department (available at www.GetAsthmaHelp.com) and distributed it to all emergency departments in the state. This group has also developed a similar discharge plan for urgent visits to other outpatient settings.

- The experience of reviewing asthma deaths has caused many of the panel members to initiate policy and procedure reviews within their own organizations.

## *Next Steps*

Investigation of these deaths from asthma has identified a number of avenues to reduce asthma mortality. Action needs to occur at many levels, including health care providers, patients and system-level changes. The findings from these investigations will continue to be shared with the many asthma stakeholders who have the expertise and position to institute these recommendations.

Further work is needed to disseminate the findings and initiate changes. Efforts needed include:

- Providing prescriptions for inhaled corticosteroids and asthma education in conjunction with ED visits as well as a system to ensure follow-up by a primary health care provider.

- Developing a basic reading level fact sheet on benefits, safety, and use of inhaled corticosteroids.

- Working with Medical and Quality Improvement Directors of Michigan health plans to enhance asthma management, particularly among Medicaid patients.

- Sharing the findings with Michigan's Tobacco program and coalitions to assist with efforts to reduce secondhand smoke exposure in homes, schools, day care settings, and workplaces.

Continued tracking of asthma deaths in Michigan is planned to identify risk factors that can be addressed to prevent such deaths. We do not have the resources to conduct in-depth investigations on all asthma deaths that occur each year, but we are able to review death certificates, day-of-death records, and medical examiner reports and findings. We can also continue investigation of deaths among children 2-18 years of age and adults 35-44 years.

The major decrease in the number of deaths between 2002 and 2007 has occurred in the older age groups where the accuracy of the reported underlying cause of death is more questionable than in the younger age groups. Our experience in conducing in-depth investigations in the 45-54 age groups clearly demonstrated this inaccuracy. The advisory panel felt that 44% of the deaths in this age group were not likely to be from asthma. For this reason, we will not pursue in-depth investigations for this age group.

Review of all 2006 and 2007 asthma deaths in the state has identified problems with the accuracy of the cause of death on the asthma death certificate. Therefore, we will continue to review this limited set of records similarly for all 2008 asthma deaths.

We also plan to continue to disseminate the information learned to educate health care providers, policy makers, and Michigan citizens to promote policy actions and system changes at state and local levels based on the panels' recommendations.

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# APPENDIX I

**More comprehensive although still de-identified case summaries are available upon request for use in educational programs for health care providers. A web based CME course with detailed information on four of the deaths can be found at www.oem.msu.edu/cme.asp.**

**2007 Case Narratives**

***Adults***

An African American woman in her fifties died from an asthma attack in the winter. The ambulance arrived and found the deceased alert and oriented, sitting on her front porch in the cold weather having severe respiratory distress. She went into respiratory arrest after she got into the ambulance. There was no next-of-kin interview or any medical records prior to the day of death. The panel did not believe there was sufficient information to comment on this case although it was concluded this was a death from asthma.

A Caucasian male in his fifties died from asthma after he called 911, walked outside into the winter and collapsed. He was diagnosed with asthma after he began working in a plastics factory. He was a welder and put on permanent disability for breathing problems approximately seven years prior to death. He had a history of atrial flutter. The panel indicated causal factors were a lack of steroid use, overuse of beta agonists, lack of avoidance of asthma triggers, inadequate prescription of steroids, lack of regular medical care and lack of health insurance for medication.

An African American female in her fifties died from asthma after being short of breath for the day. As her family transported her to the ED, she lost consciousness at which time EMS was called. Her other medical conditions included obesity, hypertension, diabetes, and cardiovascular disease. She was an ex-smoker and worked as a nurse before she went on disability. The panel felt causal factors in this death were inadequate use of steroids, compliance issues with asthma triggers (cat), and a need for referral for high-risk patient.

A Caucasian male in his fifties died from an asthma attack in the winter. He had not seen a doctor in more than twenty years and bought his medications at a gas station. It was reported he was an alcoholic and smoked one pack of cigarettes per day. The panel felt this was not an asthma death, but a death from COPD.

A Caucasian adult male died in his sleep from an asthma attack with "other significant conditions contributing to death" being intoxication. He had been intoxicated the night prior to his death. He was found unresponsive in the morning and pronounced dead at the scene. He was a cigarette smoker of 10 cigarettes per day for the past 25 years. The panel stated this was not an asthma death but a death relation to alcohol and medication (methadone).

An African American male in his forties died in the spring at his home. He was discharged four days prior to death after being hospitalized for five days. He complained of fatigue and weight loss of about 60-70 pounds over the last six months. He complained of chronic diarrhea 4-6 times per day. The deceased used alcohol, cocaine, and marijuana. Her refused several tests and was discharged home. The panel agreed that causal factors in this case included compliance issues, inadequate asthma diagnosis, inadequate prescription of steroids, and lack of health insurance.

An African American male died after a more than two week hospital admission. He had an asthma exacerbation at home, went to the ED where he was awake and alert. His other medical condition was hypertension. He smoked one pack of cigarettes per day, sometimes during his breathing treatments. The panel decided the causal factors in his death were patient compliance issues, inadequate diagnostic workup by physician, and delay in intubation at the hospital.

An African American male in his fifties was taken to the ED in an ambulance. He had vital signs and was responding in the ED but subsequently became unresponsive during the physician's physical exam and eventually died. The deceased's medical conditions included asthma, emphysema, hypertension, cardiomyopathy, congestive heart failure, arthritis and a seizure disorder. The deceased used inhaled steroids around the time of his death. The panel agreed that causal factors included multiple comorbidities, inadequate asthma diagnosis, need for referral for high-risk patient, lack of regular medical care and lack of case management.

A Caucasian female in her fifties went to the ED for an asthma exacerbation. She was admitted to the hospital and decompensated two days after admission. She was intubated, put on a ventilator, and died one day later. She had several medical problems including asthma, sinus problems, osteoporosis, diabetes, and a prolapsed mitral valve. The deceased used oxygen at home continuously at three liters per minute and was on disability for the last four years of her life because of asthma and sinus problems. The panel concluded this was not an asthma death but a death from sepsis. There was concern by the panel of an overuse of steroids.

A Caucasian female in her late forties died in her sleep from an asthma attack. She was seen in the ED two times in the year prior to death for a breathing problem. She had a history of using marijuana up until her death. The deceased's home was not clean, in a poor state of repair, and had dog hair everywhere. The panel decided the causal factors included alcohol and drug abuse, patient compliance, physician's lack of referral for high-risk patient, inadequate diagnosis by physician, and lack of regular medical care.

A Caucasian male in his fifties died nine hours after being seen in the ED and discharged because of an asthma exacerbation. It was noted the family wanted to take him home because he was getting irritated and refused hospitalization. According to his death certificate, cardiopulmonary arrest, probable ventricular arrhythmia, and acute asthma were the causes of death. The deceased was diagnosed with asthma five years prior to his death. His other medical conditions included Down's syndrome, mental retardation, arthritis, anxiety, and dysphasia. He was seen in the ED three times in the year prior to death for breathing problems. The panel concluded there was not a clear diagnosis and this was not an asthma death. The panel voiced a concern about the family's refusal of admission to the hospital.

A Caucasian male in his fifties went to the ED with chronic low back pain, dyspnea, and a cough. His chest x-ray showed consolidation. He was admitted for dyspnea and shortness of breath secondary to community-acquired pneumonia. He was prescribed IV antibiotics, Avelox, breathing treatments with humidified oxygen, Mucinex, and IV fluid hydration. He decompensated and was intubated the next day. Life support was withdrawn and he died 6 days after walking into the ED. The panel agreed this was not a death from asthma.

A Caucasian female in her late forties died of pulmonary hypertension and asthma after a 2-week hospital stay. She went to the ED because she was not improving after a round of antibiotics prescribed by her pulmonologist. She had a medical history that included Tetralogy of Fallot, which was repaired when she was a child, Rheumatoid arthritis, and a pneumonectomy. The panel believed there was not a clear diagnosis and this was not a death from asthma. There was concern by the panel about an inadequate diagnosis.

A Caucasian female in her early fifties died from an asthma attack. She became short of breath at home. While her husband was going to get the breathing machine she collapsed and became unresponsive. EMS took her to the ED where she was pronounced dead. The panel agreed causal factors included nebulizer prescription from the physician and improper use of the nebulizer.

An African American female in her late forties died at home from COPD and asthma. She died at home on the day she was discharged from the hospital after a 5-day admission for back pain. Her medical conditions included chronic lower back pain, hypertension, obesity, type 2 diabetes, COPD, and asthma. The panel concluded this was not an asthma death. The death was quite possibly from a pulmonary embolism with obesity as a contributing factor. The panel had a concern about inadequate diagnosis.

An African American male in his forties died from asthma. On the day of death, he fell down on his back in the bathtub, complained of back pain and took Motrin. It was reported that the deceased had been using his nebulizer more frequently over the past couple days. Thirty minutes later he became severely short of breath. EMS was called and by the time they arrived the deceased was pulseless with an unknown downtime. His medical conditions included diabetes, a leg injury, and asthma diagnosed five years prior to death. His home medications included Albuterol nebulizer prn, a multivitamin, and prednisone (dose unknown). The panel agreed that causal factors included

inadequate use of inhaled steroids, patient compliance, allergy triggers in the house, obesity, and a need for a referral for this high-risk patient.

A Caucasian female in her fifties died from asthma visiting to a bar in a remote area after she worked her shift as a home health aid. She left the bar to start her car before she was to drive a couple of friends home. She had no obvious signs of respiratory distress in the bar and had her MDI with her. When she did not return after a few minutes, her friends went out to check on her and found her unresponsive and face down in the parking lot. EMS were called, took her to the hospital where she was pronounced dead. She was a smoker. The panel concluded that the causal factors in this case were compliance issues (smoking cigarettes), inadequate use of inhaled steroids, and overuse of β agonists.

A Caucasian female in her early fifties had multiple medical problems including morbid obesity, obstructive sleep apnea, cor pulmonale, asthma, COPD, congestive heart failure, cardiomyopathy, pulmonary hypertension, anxiety, depression, bipolar disorder, degenerative arthritis, chronic back pain and diabetes. She had an asthma exacerbation at home and died in the ED. She had two hospitalizations in the year prior to death for breathing problems, one which required intubation for three days. The panel agreed this death was not a death from asthma.

An African American female in her late forties died in the late fall from "asphyxia due to neck swelling and asthma" per her death certificate. She had throat surgery days prior to death. Her health history included asthma, type 2 diabetes, reflux, and high cholesterol. She was on disability due to her asthma. She used oxygen at night the last six months prior to death. She smoked 20 cigarettes per day. The panel felt the causal factors in this case included inadequate use of inhaled steroids, inadequate prescription of inhaled steroids, and inadequate care or asthma associated with surgery.

A Caucasian male in his fifties died at home in his sleep from asthma. He was diagnosed with asthma as a child. His other medical conditions included chronic back pain (status post three back surgeries), coronary artery disease, and hypertension. He did not work due to back pain. He had 18 medical encounters in the last five months of life, five were for breathing problems. He smoked 20 cigarettes per day. The panel concluded the causal factors in the case were overuse of β agonists, inadequate use of inhaled steroid, depression, inadequate prescription of inhaled steroids, needed referral for high-risk patients, and lack of regular medical care for asthma.

An African American male in his fifties died in the winter from an asthma attack in the middle of the night. On the day of death, he grilled outside in the wind and cold. The deceased had 11 medical encounters in the year prior to death, six for breathing problems. His asthma was considered very poorly controlled. Although he did not smoke cigarettes, he smoked marijuana and used alcohol daily. The panel agreed that causal factors in this case included inadequate use of steroids, compliance issues, need for a high-risk referral, inadequate prescription of steroids, and excessive use of the Emergency Room in place of a primary care physician.

An African American female in her fifties died after being hospitalized for one month. The deceased was short of breath the day prior to her collapse. She "passed out" the next day and 911 was called. Medical records stated the deceased was taken to the Emergency Department (ED), admitted, and died 28 days later. She was diagnosed with asthma two years prior to death. Her medical conditions included asthma, hypertension, diabetes, schizophrenia, and obesity. She was on disability due to her schizophrenia and lived with 20 other people in the adult foster care home. She was a smoker and around smokers at home. She had daily breathing problems. The panel concluded that causal factors in this case included inadequate use of inhaled steroids, psychiatric disease, inadequate prescription of inhaled steroids, need for a high-risk referral, lack of regular medical care, and the quality of asthma care in the psychiatric foster home.

**Children**

An African American teenaged female died from asthma in the winter after waking up in the middle of the night with trouble breathing. Her parents administered nebulizer breathing treatments with no improvement. She became very pale and was not breathing well on her own, so they tried to blow air into her mouth. She went limp and EMS was called. She was pronounced dead in the ED 40 minutes later. She was hospitalized one year prior for an asthma attack with no ED visits or hospitalizations since. The deceased had a well-child physical seven months prior to death that revealed no abnormalities. The panel believed casual factors included bronchodilator overuse, inadequate use of steroids, inadequate diagnosis, lack of pulmonary function testing, need for a high-risk referral, and lack of adult supervision.

An African American female toddler died in the summer of an asthma attack. She was given hourly nebulized breathing treatments at home due to shortness of breath. CPR was in progress by the deceased's parents at the time of EMS's arrival. She was pronounced dead in the ED after more than 30 minutes since the time of the asthma attack. The panel discussed possible causal factors such as bronchodilator overuse and delayed ED treatment but there was limited case information.

An African American teenager died from asthma in the fall. He had trouble breathing and gave himself a breathing treatment. His mother heard him scream and then hit the ground. She attempted CPR prior to EMS arrival. He was pronounced dead in the ED. Although the panel believed there was not enough information provided, they discussed the causal factor of lack of adequate adult supervision.

A Caucasian female in elementary school died in the summer. The deceased's sister adopted the deceased after their mother died approximately one year prior to the deceased's death. The deceased had several medical conditions including cerebral palsy, developmental delay, blindness, VP shunt, and gastroesophageal reflux disease (GERD). She had no (symptoms) and was never diagnosed with asthma so it was surprising to the family that this was an asthma death. The panel believed an inadequate asthma diagnosis was the causal factor.

An African American male in elementary school died in the late fall from an asthma attack after coming home from a religious service. His medical conditions were asthma and eczema. He was seen twice by his primary care physician (PCP), four times in the ED and was hospitalized 2-3 times in the year prior to death for breathing problems. The deceased was seen by his PCP more than 11 months prior to death for a well-child visit and was said to have mild persistent asthma that was controlled. The panel concluded the causal factors included inadequate prescription and use of steroids, missed appointments, need for high-risk referral, inadequate diagnosis, lack of health insurance, and questionable adult supervision.

An African American male in elementary school died from asthma in the summer. On the day of death, the deceased began having trouble breathing and took a breathing treatment while his mother was downstairs. A sibling alerted his mother there was something wrong with the deceased and 911 was called. His medical conditions included asthma and eczema. The deceased was seen by his primary care physician 4-5 times, in the ED 3-4 times, and hospitalized one time in the year prior to death. A relative voiced concern about the deceased and his siblings being left alone unattended. The panel discussed causal factors which included inadequate prescription and use of steroids, lack of parental supervision, lack of high risk referral, and the lack of regular maintenance health care visits.

An African American male in his teens, who had asthma most of his life, died from an asthma attack in the fall. On the day of death, after walking back and forth to a religious service, he began having breathing problems and used his nebulizer. His brother reported to his mother, who was napping, that the deceased wasn't taking his medications anymore. The deceased became unresponsive and died in the ED. In the year prior to death, the deceased was seen in the ED four times and hospitalized four times for a breathing problem. The panel agreed that causal factors included inadequate use of steroids, no appreciation for the severity of the asthma, need for a referral for such a high risk patient to a specialist, lack of prescription of inhaled steroids in the ED and lack of adequate adult supervision.

An African American preteen died from an asthma attack one evening after taking a bath. He went to his mother's bedroom and appeared to be out of breath. He turned on the nebulizer and a short while later his mother heard him yell "I'm about to die". His sister called to his mother and stated the deceased passed out in her arms. He was diagnosed with asthma as an infant. His other medical conditions were GERD, allergic rhinitis, and atopic dermatitis. He saw both an allergist and pulmonologist in the year prior to death. He was around cigarette smoke at home. The panel felt causal factors included second hand cigarette smoke exposure, bronchodilator overuse, need for an additional referral to a specialist for such a high risk patient, and lack of adequate adult supervision.

An African American female in elementary school died from an asthma attack after becoming short of breath while playing outside. She started to turn blue and passed out in front of her mother. She was pronounced death in the ED. She was seen in the ED at least three times and hospitalized once for a breathing problem in the year prior to death. She had asthma symptoms 3-4 times per week and had a cough almost nightly. The panel agreed causal factors included bronchodilator overuse, inadequate use of steroids, need for referral for high-risk patient, and the use of Xolair.

A Caucasian male in elementary school died in his sleep from an acute exacerbation of chronic asthma. The deceased had several co-morbid conditions including cerebral palsy, asthma, scoliosis, seizures, sleep apnea, GERD, congenital dysplasia of bilateral acetabulum, and a recent hip/leg fracture. He was wheelchair dependent and needed full assistance with transfers and activities of daily living. He usually contracted pneumonia in the winter which caused him to be hospitalized more than twenty times and intubated once in his life. The panel decided the causal factors in this case included the need for referral for high-risk patient, no asthma action plan, delayed EMS initiation, and no CPR by parents.

A Caucasian male in elementary school died of an asthma attack after two medical encounters less than 24 hours prior to death for fever, a cough, and trouble breathing. His grandmother agreed to be interviewed and stated the deceased's parents did not know he had asthma. His other medical condition included autism. He was toilet trained and was able to babble. On several occasions his parents could not afford medications for the deceased and his autistic brother. The panel questioned that the death was caused by asthma and the questionable premature discharge from the ED just prior to death.

# APPENDIX II

## Members of Adult and Child Asthma Mortality Review Panels

### 2007 Adult Asthma Mortality Review Panel Members

John Armstrong, MD
Private Practice
Pulmonologist

Susan B. Blonshine, RRT, RPFT, FAARC
Private Consultant
Respiratory Therapist/Asthma Educator

Ridhu Burton, MD
Private Practice
Allergist

Larry Hennessey, MD
Private Practice
Allergist

Dana Kissner, MD
Wayne State University
Pulmonologist

Thomas P. Miller, MD
Private Practice
Allergist

Les Puretz, DO
Ingham Regional Medical Center
Emergency Medicine Specialist

Edward Zoratti, MD
Henry Ford Hospital
Allergist

## 2007 Child Asthma Mortality Review Panel Members

Karen Boyd, MSW
Michigan State University
Social Worker

Debbie Eggleston, MD
Michigan Dept Community Health
Medical Advisor

James Forshee, MD
Molina Health Care of Michigan
Chief Medical Officer

Duane Harrison, MD
Private Practice
Allergist

Steven Kreshover, MD
Private Practice
Allergist

Karen Meyerson, RN, BSN, AE-C
Pediatric and Adult Asthma
Network of West Michigan
Asthma Educator/Caseworker

Paul Munzenberger, PharmD
Wayne State University
Pharmacist

Elizabeth Secord, MD
Children's Hospital of Michigan
Pediatric Allergist/Immunologist