Causes of Birth Defects: An Epidemiological Mystery

by Trish Strohfeldt

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In collaboration with the Centers for Disease Control and Prevention's
Jennita Reefhuis

In this lesson students will be presented with a problem – a cluster of unexplained neural tube birth defects are occurring in a town. Students will take on different roles (physician, parent, epidemiologist, lab technician, etc.) to investigate possible causes of the increased occurrence of birth defects, and then use the evidence gathered to propose the most probable cause. The focus of the lesson is to better understand the process of investigating a scientific problem and the many risk factors associated with birth defects.

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Summary
In this lesson students will be presented with a problem a cluster of unexplained neural tube birth defects are occurring in a town. Students will take on different roles (physician, parent, epidemiologist, lab technician, etc.) to investigate possible causes of the increased occurrence of birth defects and then use the evidence gathered to propose the most probable cause. The focus of the lesson is to better understand the process of investigating a scientific problem and the many risk factors associated with birth defects.

Learning Outcomes

- The student will become more familiar with how the scientific process works (several groups working together, research, revising a hypothesis, sharing information) when investigating the cause of a cluster of a disorder "Become more familiar" seems like a broad objective.
- The student will be able to describe risk factors associated with birth defects
- The student will be able to describe the many roles of the people (physician, epidemiologist, lab technician, etc.) involved with studying the probable cause of a cluster.

Materials

1. Computers with access to Internet for each student.
2. Copies of handouts for each student ("Pretest" and "'Investigation Sheet" from the Introduction, and "Rubric for the Final Report" from the Conclusion)

Total Duration 2 hours

Procedures

Teacher Preparation
The teacher should make photocopies of the required handouts ("Pretest" and "'Investigation Sheet" from the Introduction, and "Rubric for the Final Report" from the Conclusion) for each student. The teacher needs to put together enough copies of each of the case file folders so that each student assigned each role has a folder for his/her role that contains the necessary files. If Internet access is not available for every student, the teacher should go to the Web resources listed for each role in Step 2 and print out the pages to put in the files In Step 2, the teacher should give each student different resources (copies of the Web sites listed for each role and any files for each role) to encourage them to work together, share information, and solve the problem. It is suggested to make the copies for each file a different color for easy sorting (for example, all parent files blue, all physician files red, etc.).

Several references are listed below that a teacher might want to explore before beginning the lesson.

References

1. Hwang B-F, Magnus P, Jaakkola JJK. Risk of specific birth defects in relation to chlorination and the amount of natural organic matter in the water supply. Am J Epidemiol. 2002; 156:374-82. http://aje.oxfordjournals.org/cgi/content/full/156/4/374

2. Dodds L, King WD. Relation between trihalomethane compounds and birth defects. Occup Environ Med. 2001 Jul;58(7):443-6. http://oem.bmjjournals.com/cgi/content/full/58/7/443

3. Texas Department of State Health Services. Neural Tube Defects and the Texas-Mexico Border [online]. 2005. [cited 2005 July 29]. Available from URL: http://www.dshs.state.tx.us/birthdefects/ntd%5Fborder.shtm

4. Birth defects in the lower Rio Grande Valley-A special report of the Texas birth defects monitoring division. December 15, 1998. Available from URL: www.dshs.state.tx.us/birthdefects/Data/bd96delv.pdf

Introduction **Time: 30 minutes**

Begin the lesson by giving the "Pretest" to the students. Have them try to complete the questions and then discuss their responses. Answers are provided in the "Pre-Test Answer Key" for the teacher's reference; however do not review the answers with the students yet, as they will be researching these topics as they work through the lesson.

Read the introduction "Request for Investigation" about the reports of birth defects. Encourage students to write down on their "Investigation Sheet" any facts that they think might be important later in their investigation of the cause of the defects. After reading the Request for Investigation and briefly discussing the problem, assign each student a role to play in the investigation. The roles are parents, primary care physicians, epidemiologists, and lab technicians.

Supplemental Documents

Title: Pretest
File Name: Pretest Birth Defects.doc
Description: This file is the pretest that should be given and discussed before beginning the lesson.

Title: Pretest Answer Key
File Name: Pretest Birth Defects – Answer Key.doc
Description: This file is the answer key to the pre-test given to the students before beginning the lesson. Do not provide the students with the answers to the pretest questions, as they will be researching these topics throughout the lesson.

Title: "Request for Investigation"
File Name: Request for Investigation.doc
Description: This file is the introductory request for investigation that should be read to the class as the background on the problem that is occurring.

Title: "Investigation" Sheet
File Name: Investigation Sheet.doc
Description: This sheet provides a structured space for each student to use for taking notes and gathering evidence during the introduction and during their investigation.

Step 2 **Duration: 45 minutes**

Have the students get into groups with the other members of the same team (all physicians together, all parents together, etc.) and distribute to each person the group-specific file folders prepared by the teacher. During this time each student will read the information in his/her file folder, use the listed Web resources, and then discuss the information with the other members of the group (i.e., all the parents will discuss their personal experiences with each other, all the physicians will compare the case histories of their patients, etc.). Note that while the "Request for Investigation" is based on a real cluster of birth defects, the patients' files that the students will be working on are not real data. As the students discuss their findings, they should take notes on the "Investigation Sheet" that they began during the reading of the Introduction.

Physician File Folder and Resources

Web Resources

Title: Birth Defects: Medical Progress in the Prevention of Neural Tube Defects
URL: http://www.cdc.gov/ncbddd/bd/mp.htm
Description: This Centers for Disease Control and Prevention Web site includes background information on neural tube defects. The "physicians" should use this information in their discussion about the birth defects mystery.

Title: Birth Defects Risk Factor Series: Neural Tube Defects
URL: http://www.dshs.state.tx.us/birthdefects/risk/risk7-NTDS.shtm
Description: This Texas Department of State Health Services Web site includes information to introduce the "physician" team members to what a neural tube defect is and some of the possible causes of NTDs.

Title: National Institutes of Health: Neural Tube Defects
URL: http://health.nih.gov/result.asp/464
Description: This National Institutes of Health Web site includes basic background information on the causes and treatments of neural tube defects. This site should be used by the "physicians" to gather information of what a neural tube defect is.

Supplemental Documents

Title: Patient File 1: Gabriella Perez
File Name: Patient File 1doc
Description: This file should be used by the "physician" group to gather information about one of the patients. Note that this is not real data.

Title: Patient File 2: Rosa Calderon
File Name: Patient File 2.doc
Description: This file should be used by the "physician" group to gather information about one of the patients. Note that this is not real data.

Title: Patient File 3: Gina Soberon
File Name: Patient File 3.doc
Description: This file should be used by the "physician" group to gather information about one of the patients. Note that this is not real data.

Parent File Folder Resources

Web Resources

Title: Spina Bifida Association Homepage: Just the Facts

URL: http://www.sbaa.org/site/PageServer?pagename=nrc_FAQ
Description: This Spina Bifida Association Web page provides background on spina bifida for the “parent” group.

Title: March of Dimes Diabetes and Pregnancy
URL: http://www.marchofdimes.com/professionals/681_1197.asp
Description: This March of Dimes Web site provides background information for the “parent” group on having diabetes and its effect on pregnancy.

Supplemental Document
Title: Parent Opinions
File Name: Parent Opinions.doc
Description: This file should be used by the "parent" group to gather information about the case. It includes "interviews" with community members on what they think is causing the birth defects in the area. Note that this is not real data.

Epidemiologist File Folder Resources
Web Resources
Title: Maternal Obesity and Pregnancy: Weight Matters
URL: http://www.marchofdimes.com/professionals/15637.asp
Description: This is a PDF file from the March of Dimes about the relationship between maternal obesity and birth defects. This site is for the "epidemiologist" group to use during their research.

Title: March of Dimes Diabetes and Pregnancy
URL: http://www.marchofdimes.com/professionals/14332_1197.asp
Description: This is a site from the March of Dimes about the relationship between diabetes and birth defects. This site is for the "epidemiologist" group to use during their research.

Title: March of Dimes and Folic Acid
URL: http://www.marchofdimes.com/professionals/14332_1151.asp
Description: This is a site from the March of Dimes about the relationship between folic acid and birth defects. This site is for the "epidemiologist" group to use during their research.

Title: Texas Department of State Health Services
URL: http://www.dshs.state.tx.us/birthdefects/risk/risk7%2Dntds.shtm
Description: This is a site from the Texas Department of State Health Services about the possible causes of neural tube defects. This site is for the "epidemiologist" group to use during their research.

Supplemental Document
Title: Increase in NTD Request for Investigation
File Name: Increase in NTD News Release
Description: This is a request for investigation for the "epidemiologist" group to use during the investigation. This release is based on the real rates of NTDs at the time of the Brownsville cluster case study. (source: http://www.wpi.edu/News/TechNews/010123/pollution.shtml)

Lab Technician File Folder Resources

Web Resources

Title: Drinking Water and Health: What you need to know
URL: http://www.epa.gov/safewater/dwhealth.html
Description: An article about toxic chemicals that have made their way into our groundwater for use by the "lab technician" group's research. It should be noted by the teacher that there is not enough known about chemical's effects on a developing fetus to determine whether or not they contribute to the occurrence of birth defects.

Title: CDC ToxFAQs
URL: http://www.atsdr.cdc.gov/toxfaq.html
Description: A Web site for the "lab technician" group to use that has fact sheets on toxic substances listed in alphabetical order. The fact sheets include information about the chemical, what it is used for, and its effects on the environment and humans. The lab technicians might want to refer to the "Water Quality Report" for chemicals to investigate. It should be noted by the teacher that there is not enough known about the effects of chemicals on a developing fetus to determine whether or not they contribute to the occurrence of birth defects.

Title: Anti Epilepsy drug can increase risk of Spina Bifida
URL: http://www.asbah.org/Spina%20Bifida/Epilepsy%20Medication.html
Description: This Web site has a brief statement about the epilepsy drugs that are linked to NTDs in women with epilepsy. This site is to be used by the "lab technician" group.

Supplemental Document

Title: Water Quality Report
File Name: Water Quality Report
Description: This file is a water quality report form a river in the area of the NTD cluster for the "lab technician" group to use during their research. This file is based on an article that studied the water in Texas. In some areas of the Texas the rates of trihalomethanes exceed the limits set by the EPA (source: http://www.uswaternews.com/archives/arcquality/1chlbyp9.html)

Conclusion **Duration: 45 minutes**

Students will now reorganize as groups that contain one of each of the roles from the investigation. Each group member will present the evidence that was gathered from his/her individual research team, and the new groups will prepare a final report showing what they think is the most probable cause of the neural tube defects in the town. After the town hall meeting, a final report will be prepared by the group and submitted for evaluation. The report will be evaluated based on the "Rubric for the Final Report" document included below.

The group will also participate in a simulated "Town Meeting" where they will share their findings and conclusions. During this Town Meeting, students will represent members of the community and members of the town board. On the day of the meeting, the teacher will hand out cards to students as they enter – some students will be designated as town board members. These students will sit at the front of the room and represent the board. They will listen to each of the speakers. One person to represent each of the groups will speak to the town board to share what they have found. After the town meeting the teacher should discuss the real facts of the case that this simulation was based upon. This information is found in "The Real Case". One point that teachers should emphasize is that public health not only identifies causes of problems, but seeks to prevent them. Once an investigation is concluded, public health professionals try to use what they have learned to prevent future problems from happening. In

the real case that this lesson plan is based on, efforts to lower the rates of neural tube defects in the area continue.

Supplemental Documents
Title: Rubric for the Final Report
File Name: Report Rubric.doc
Description: This file is the rubric that can be used by the teacher to assess the groups' final reports on the case.

Title: The Real Case
File Name: The Real Case.doc
Description: This file is the information about the actual cluster of neural tube defects for the teacher to share with the students after the town hall meeting.

Assessment

The students will be assessed on their written final report using the "Rubric for the Final Report" found in the conclusion step.

Modifications

Extensions
The teacher can have the students create an intervention or prevention plan for the town. The plan could include a campaign with brochures or posters about ways to prevent neural tube defects.

Other Modifications
The amount of material in the file folders could be reduced or expanded to increase or decrease the difficulty. The file folders could be eliminated entirely to make the research less guided and more challenging. However, in this case the names of the county (Cameron) and town (Brownsville) in Texas should be changed to fictitious names so that the students don't find the real story and the real outcome during the research phase.

Education Standards

National Science Education Standards
Science as Inquiry, CONTENT STANDARD A:
As a result of activities in grades 9-12, all students should develop

- **Abilities necessary to do scientific inquiry**
- **Understandings about scientific inquiry**

Science and Technology, CONTENT STANDARD E:
As a result of activities in grades 9-12, all students should develop

- **Abilities of technological design**
- **Understandings about science and technology**

Science in Personal and Social Perspectives, CONTENT STANDARD F:
As a result of activities in grades 9-12, all students should develop understanding of

- **Personal and community health**

- Population growth
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Pretest

Causes of Birth Defects: An Epidemiological Mystery
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Think about what you already know about birth defects.

1. What do you know about the causes of birth defects, or what contributes to them?

2. List the names of any birth defects that you know. If you don't know their names then describe the characteristics of the defect.

3. What are some of the ways that birth defects can be prevented?

4. What processes or steps do you think are taken to determine the cause of a cluster of birth defects (when more than a normal rate of birth defects in a certain population is seen)?

Pretest Answer Key

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Think about what you already know about birth defects.

1. What do you know about the causes of birth defects, or what contributes to them?

Some examples are included in the following list (1,2)

a. Behavioral (smoking, drinking, etc.)
b. Maternal age, weight
c. Maternal diabetes
d. Genetics or "runs in families"
e. Unknown cause

2. List the names of any birth defects that you know. If you don't know the name then describe the characteristics of the defect.

Some examples might include spina bifida, cleft lip/palate, heart defects, or other birth defects that they have seen on TV or affect family members. (2,3)

3. What are some of the ways that birth defects can be prevented?

Some examples include not smoking or drinking during pregnancy, taking prenatal vitamins with folic acid before and during pregnancy, and achieving good gylcemic control before and during pregnancy for women with diabetes. (2,4)

4. What processes or steps do you think are taken to determine the cause or contributors of a cluster of birth defects (when more than a normal rate of birth defects in a certain population is seen)?

First, you might identify the group of birth defects as a cluster, and then identify possible connections between cases. During this investigation, you might look to doctors, parents, epidemiologists, lab technicians, and others to help determine why this cluster occurred. (5)

References

1. Kucik, J. Surveillance and Epidemiology [presentation]. CDC's Science Ambassador Workshop, 2005.
2. March of Dimes. Birth Defects [online]. 2005. [cited 2005 July 29]. Available from URL: http://www.marchofdimes.com/professionals/14332_1206.asp.
3. National Institutes of Health. Neural Tube Defects [online]. 2005. [cited 2005 July 19]. Available from URL: http://health.nih.gov/result.asp/464.
4. CDC. Medical Progress in the Prevention of Neural Tube Defects [online]. 2005. [cited 2005 July 19]. Available from URL: http://www.cdc.gov/ncbddd/bd/mp.htm.
5. Honein, P. Reefhuis, J. Risk Factors for Birth Defects [presentation]. CDC's Science Ambassador Workshop, 2005.

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**********Request for Investigation*********

Date: May 24, 2005

Re: Recent Cluster of Birth Defects in Cameron County Texas

In the past three days there have been three cases of neural tube defects (NTDs) in Brownsville, Texas.. NTDs are serious birth defects of the brain and spine that include anencephaly and spina bifida.

Epidemiologists from the Centers for Disease Control Prevention have been called in to investigate this cluster of birth defects. The epidemiologists are working with the doctors and the Texas Department of State Health Services to try to determine the cause of the cluster of NTDs.

There are many possible causes for this cluster of NTDs. It is possible that factors including maternal diet, race, or age, or health conditions like diabetes, or behaviors like smoking by the mother may be associated with the cluster. Many people in the area suspect an environmental cause, like water pollution. Cameron County Texas is located on the Mexican Border and has a population of 270,524. The population is over 80% Hispanic and over 40% of the population is classified as having a low income.

Your Role:

Each of you will be assigned a role in this investigation. As you assume your role you will research the cases in Cameron County and try to determine the cause of the birth defects in that area. Once you have pinpointed a cause you will need to make a recommendation to the town as how best to correct the problem and create an intervention or prevention system.

Good Luck!

Note:
This investigation is actually based on an outbreak of NTDs that occurred in Cameron County in 1991. Please visit the following Web site for more information:
Texas Department of State Health Services. Neural Tube Defects and the Texas-Mexico Border [online]. 2005. [cited 2005 July 29]. Available from URL:
http://www.dshs.state.tx.us/birthdefects/ntd%5Fborder.shtm

"Investigation" Sheet

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Team Assignment: (doctor, parent, etc.): _____

Request for Investigation
Notes on the Case (Write down any important facts from the "Request for Investigation".)

Researching with other Team Members
Notes on the Case (Write down important information you find as you research your assigned file and Web resources.)

Conclusions
What I think is causing the NTDs (Write down what is causing the NTDs in this area. Give evidence to support your response.)

Patient File 1: Gabriella Perez
(Not Real Data)

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Midtown Medical Center
12290 W. Townhall Road

Patient File

Date: 7/27/05

Name: Gabriella Perez

Address: 3290 N. 5th Street

Date of Birth (DOB): 5/22/05

Sex: female

Age: 2 months

Race: Hispanic

Patient History:
Gabriella Perez is a 2-month-old baby girl with big brown eyes and a few tufts of brown hair. She is very calm when you examine her and even gives you a smile. Gabriella was born with spina bifida. Her mother reports that she started taking a prenatal vitamin as soon as she found out she was pregnant, but she did not realize that she was pregnant until her 3rd month of pregnancy. Gabriella's mother also reports that she was diagnosed with type II diabetes about two years ago. Two prior siblings were born with no neural tube defect, and there was no other family history of NTDs. Both parents are overweight and are smokers. Gabriella's mother tells you that she is overwhelmed by her daughter's health care needs, and wants you to tell her why Gabriella has spina bifida.

Patient File 2: Rosa Calderon
(Not Real Data)

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Midtown Medical Center
12290 W. Townhall Road

Patient File

Date: 7/15/05

Name: Rosa Calderon

Address: 4900 N. 7th Street

Date of Birth (DOB): 5/20/74

Sex: female

Race: Hispanic

Patient History:
Rosa Calderon is a Hispanic woman in her 30s who has come to see you after the child she was carrying in her most recent pregnancy was diagnosed with anencephaly. She reports that there is no family history of such defects and that she previously had two healthy pregnancies. She also reports that she doesn't smoke or drink alcohol, and that she did not take vitamins or any medications during the pregnancy. She tells you that her pregnancy had gone well until the anencephaly was diagnosed in her 5th month. Both Rosa and her husband have a history of kidney problems, and Rosa has type II diabetes. The baby that she was carrying was a boy who she named Manuel. Rosa is devastated and wants you to help her understand why this happened.

Patient File 3: Gina Soberon
(Not Real Data)

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Midtown Medical Center
12290 W. Townhall Road

Patient File

Date: 7/10/05

Name: Gina Soberon

Address: 3400 W. Cherry Street

Date of Birth (DOB): 5/22/05

Sex: female

Age: 2 months

Race: Hispanic

Patient History:
Gina Soberon is a 2-month-old baby girl who was born with spina bifida. She is an active baby who squirms the entire time you examine her. Her mother, Maria, is a young woman who works at the chemical plant in town. This was Maria's first pregnancy, although she had several miscarriages in the past 2 years. Maria tells you that she has no family history of NTDs. Maria tells you that she smokes occasionally, but tried to avoid smoking while she was pregnant. She does not use drugs or drink alcohol. She is of average weight. Maria started taking a multivitamin with folic acid as soon as she found out that she was pregnant. Maria and her husband feel strongly that Maria's exposure to chemicals at her job caused Gina's spina bifida, and they would like you to investigate further.

The Opinion of the Parents

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Andrea Villegas, 45, 2 children

"I used to hear from my grandmother that birth defects like these are caused by the pregnant mother going outside during a lunar eclipse, the mother being frightened by an animal, the mother falling down and hitting her stomach, or because the family is being punished by God. I don't agree with any of those beliefs, but it sure makes you wonder if there is any truth to any of them. However, I personally think that the cluster of these birth defects is just an unlucky happening. I feel really bad, but I don't think it is anything that the mothers could have done something about."

Eloisa Lopez, 25, no children

"I know that in school we learned about all kinds of things that get into our air and our water that can make you sick. We have a lot of factories in the area that are always dumping stuff into our air and water. They say it is safe, but I am not so sure. We have been lied to before."

Pedro Gonzales, 88, 5 children, 20 grandchildren

"I have lived here all my life and so have my children and grandchildren. They are pretty healthy. They have had a few problems with miscarriages, but no one has had a birth defect or cancer. I am not sure what caused this, maybe the mothers were not very healthy?"

Lupe Chavez, 32, 5 children

"My neighbor is one of the mothers of a child that was recently born with a neural tube defect and passed away. My children are also not very healthy. They weren't born with a birth defect, but they are sick a lot and have problems with their liver function. We live near a pond that is very discolored; the water is kind of pink. I really think that whatever is in the pond may be what is making them sick."

Pablo Sanchez, 66, 1 child, 3 grandchildren

"I have heard that people have different chances of being affected by something like this, depending on their ethnicities. I wonder if this is true for this situation in our town."

Note that these opinions have been created for this lesson and are not real. Their intent is to spark conversation and not to be used as facts in exploring the possible cause of this outbreak.

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==========Request for Investigation==========

Date: 8/2/04

Centers for Disease Control and Prevention

During the past two years a significant increase in neural tube defects has been seen in one area in southern Texas. The national rate for NTDs is 10 per 10,000 births. (1) In the past two years the rate in this area has been 13 per 10,000 births; before it was 11 per 10,000.

Please investigate possible causes and prevention of these defects.

Reference

1. CDC. Medical Progress in the Prevention of Neural Tube Defects [online]. 2005 [cited 2005 July 29]. Available at URL: http://www.cdc.gov/ncbddd/bd/mp.htm.

Note that all other information is simulated and not real data.

==========Water Quality Report==========

8/4/05

Site: Quass River

PCB's: normal range

Chlorine: normal level

Lead: normal range

Trihalomethanes: normal range

Arsenic: normal range

Final Group Report Rubric

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Directions
Each group will get together after the town hall meeting to compile their thoughts and create a final report of the birth defects mystery.

Part 1: Introduction	
-Include group members and role	5pts.
-Give background on the problem (what is a NTD, what is happening)	10pts.
-Give initial thoughts on cause	5pts.
Part 2: Body	
-Pick three possible causes and discuss the evidence and reasoning for each. Discuss evidence you found as well as evidence presented at the town hall meeting	15pts.
Part 3: Conclusion	
-Pick one of the three causes that you think is most likely to be the reason for the cluster of birth defects. Defend your reasoning with information you found.	10pts.
-Discuss what can be done to prevent further birth defects.	10pts.
Typed, double-spaced	5pts.
Complete sentences, paragraphs, grammar	5pts.

The Real Case

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In 1991 there was an unusual cluster of anencephaly cases (a type of neural tube defect) that occurred in Brownsville, Texas (a southern border community). Within 36 hours three babies were born (and died shortly thereafter) with a neural tube defect. The Texas Department of State Health Services and the Centers for Disease Control and Prevention (CDC) worked together to try to determine the cause of this cluster. (1) Epidemiologic investigations revealed that among children born to Hispanic mothers, a higher than expected rate of neural tube defects was observed. (2) Many causes were suspected at the time, including mothers not consuming the recommended 400 micrograms of folic acid before and during pregnancy, maternal obesity and diabetes, and chemicals in the area from water pollution. The Texas Department of State Health Services and the CDC were not able to determine the cause of the cluster in Brownsville; however this cluster highlighted the need for more birth defects surveillance, research and prevention activities in Texas. Since this outbreak, the Texas Health Department is still tracking and studying NTDs and other birth defects in the region. During the 1991 cases a special task was set up that is still in place to study birth defects. (1,2,3)

References

1. Texas Department of State Health Services. Neural Tube Defects and the Texas-Mexico Border [online]. 2005. [cited 2005 July 29]. Available from URL: http://www.dshs.state.tx.us/birthdefects/NTD_border.shtm.

2. Texas Department of State Health Services. Birth Defects Epidemiology and Surveillance [online]. 2005. [cited 2005 July 29]. Available from URL: http://www.dshs.state.tx.us/birthdefects/default.shtm.

3. Bureau of Epidemiology, Texas Department of Health. Ten Years After…Monitor [serial online] 2001 Dec [cited 2005 July 29]; 7(2): Available from URL: http://www.dshs.state.tx.us/birthdefects/monitor/vol7-2.pdf.