

EXECUTIVE SUMMARY

INTRODUCTION

This report, both in its format and its content, is intended to meet the needs of several audiences: professional scientists and risk assessors; policy makers at the state, County and local levels; and community members or other interested individuals who may or may not be familiar with this geographic region and/or the natural gas industry. Thus, some of the information included in this report is not typically found in an environmental or health risk assessment study report. We hope, however, that the additional information will add to the understanding of the diverse audience that the study was designed to serve. Similarly, in *Part II, Health Study*, we have presented statistical health outcomes data from several different sources as a means of providing validation and/or contrast with the results of the self-reported household survey data and among the various hospital, insurance provider and state-based data sources that were available to us.

Oil and gas activity within Garfield County has generated public concern with regard to impacts on both the environment and public health. As a result, the Garfield County Commissioners approved using funding from a fine levied against EnCana Corporation by the Colorado Oil and Gas Conservation Commission to conduct a comprehensive study of health and environmental risks to residents of Garfield County. The study, conducted over a period of approximately three years, had two major components: a risk analysis based on environmental exposure data and modeling and a comprehensive health study that creates a baseline assessment of the health of Garfield County residents.

The primary focus of this health and risk assessment study is Garfield County. Mesa, Montrose, and Delta Counties were selected as comparison counties for the health assessment portion of the study. All four counties are located on the Western Slope of Colorado and share similar social and political cultures and population demographics. All four counties have experienced energy and mining activities and the accompanying cycles of economic growth and recession (“boom and bust”), as well as environmental and social impacts. Currently, however, Mesa, Montrose and Delta Counties are experiencing relatively fewer impacts from natural gas industry drilling and processing activities. In addition, the four counties have overlapping healthcare networks and service areas, which made it easier to acquire comparative health data.

PART I – RISK ASSESSMENT

Risk was evaluated for human exposure to pollutants associated with natural gas operations in air, water, and soil in Garfield County. A general lack of data on pollutant concentrations in the environment limited the assessment. With respect to air, pollutant concentrations were generated through a mathematical model to supplement the concentrations collected by sampling and analysis during the *Garfield County Ambient Air Quality Monitoring Report, June 2005-May 2006*. With respect to water and soil, a more qualitative evaluation was performed in lieu of data on pollutant concentrations.

A Gaussian plume model was used to make a plausible prediction of air pollutant concentrations that may occur during natural gas operations. The model was based, to the degree possible, on the meteorological conditions specific to Garfield County, and was applied to five specific natural gas operations: flow back during well completion with no recovery of natural gas, flow back with 93% recovery of natural gas, wellhead glycol dehydration, uncontrolled emissions from condensate tanks, and condensate tank emissions controlled by a combustion device. The pollutant concentrations generated by the model were then used in risk calculations based on the U.S. Environmental Protection Agency's *Risk Assessment Guidance for Superfund, Volume 1. Human Health Evaluation Manual (Part A)*.

The Environmental Protection Agency (EPA) advocates as a *goal* that cancer risk for a specific exposure be no more than 1 chance in 1 million. The EPA further specifies that a cancer risk of up to 1 chance in ten thousand is considered acceptable. The results of the risk assessment indicate that the EPA's acceptable value for cancer risk can be exceeded for benzene in air for the following situations:

- For flow back with no gas recovery, the 70-year exposure exceeds the acceptable range for distances up to 500 meters (550 yards) downwind of the well.
- For flow back with 93% recovery of gas, the 70-year exposure exceeds the acceptable range for distances up to 75 meters (82 yards) downwind of the well.
- For emissions from wellhead glycol dehydration units, the 70-year exposure exceeds the acceptable range for distances up to 50 meters (55 yards) downwind of the well.
- For VOC emissions of twenty tons per year from condensate tanks, the 70-year exposure exceeds the acceptable range for distances up to 100 meters (110 yards) downwind of the tank.

Benzene emissions during uncontrolled flow back present the greatest cancer threat. However, the risk of cancer exceeds the EPA acceptable range only for a seventy-year exposure. An exposure of that duration to uncontrolled flow back appears unlikely. A 70-year exposure to dehydration unit and condensate tank emissions may be more plausible, depending on the actual production life of natural gas resources in Garfield County.

The results of the risk assessment for air also indicate that reference concentrations for non-cancer effects may be exceeded for some situations. Reference concentrations are pollutant concentrations in air representing thresholds below which health effects are very unlikely to occur. Reference concentrations have been developed for acute exposures (one to fourteen days), intermediate exposures (fifteen to 364 days), and chronic exposures (seven years to a lifetime). Modeling results indicate that reference concentrations can be exceeded in the following situations:

- For flow back with no gas recovery, the benzene acute reference concentration of 30 micrograms per cubic meter is exceeded for distances up to 250 meters (275 yards) downwind.
- For flow back with no gas recovery, the benzene intermediate reference concentration of 20 micrograms per cubic meter is exceeded for distances up to 300 meters (330 yards) downwind.
- For flow back with no gas recovery, the benzene chronic reference concentration for benzene of 30 micrograms per cubic meter is exceeded for distances up to 250 meters (275 yards) downwind.
- For flow back with no gas recovery, the *m,p*-xylenes chronic reference concentration of 100 micrograms per cubic meter is exceeded for distances up to 100 meters (110 yards) downwind.
- For emissions of VOCs at twenty tons per year from condensate tanks, the *m,p*-xylenes chronic reference concentration of 100 micrograms per cubic meter is exceeded for distances up to 50 meters (55 yards) downwind.

These results suggest that emission of benzene during uncontrolled flow back is the situation that presents the greatest threat of non-cancer effects. These effects may occur in people who spend one day or more within a distance 250 meters downwind of the natural gas well when this operation is taking place. The non-cancer effects of benzene include neurotoxicity and depression of bone marrow function, resulting in blood disorders (decreased counts of specific blood cells, such as erythrocytes, leukocytes, and thrombocytes) and impairment of the immune system.

There are a number of uncertainties in the non-cancer threat and cancer risks determined using pollutant concentrations based on the Gaussian plume model. Some of these uncertainties have the effect of understating threat and risk; others have the effect of overstating threat and risk. The report includes a discussion of these uncertainties.

Garfield County residents have expressed concern about possible effects on ground water and surface water used for drinking and other purposes. Natural gas operations do have the potential to create water contamination, and have done so in certain well-publicized instances. However, because of a lack of water data representative of broad areas of the county, a quantitative risk assessment for ingestion of contaminated ground water or surface water was not performed. Contaminant pathways and drinking water standards are discussed in a qualitative manner instead. Similarly, given the limited data on soil pollutant concentrations, only a qualitative evaluation was performed for possible human health effects from exposure to contaminated soil.

Several recommendations are offered based on the risk assessment. The recommendations, detailed in the report and summarized at the end of the *Executive Summary*, focus on filling in data gaps in order to make a better evaluation of risk, and on the use of best management practices such as “green completions”.

PART II – HEALTH ASSESSMENT

Two questions guided data collection for this part of the study:

1. Is the health of residents of Garfield County different than the health of residents of Delta, Mesa or Montrose counties?
2. Is the health of residents of areas of Garfield County that are heavily impacted by the natural gas industry different from the health of residents of less impacted areas of Garfield County?

To answer these questions, data were collected in four ways:

- Public perceptions, concerns and experiences were identified through focus groups, public meetings, interviews with key informants, and by reviewing logs of complaints that had been received by the Garfield County Health Department.
- Quantitative health indicators and outcomes were obtained through two complementary methods:
 - collecting and analyzing health data that are reported annually to the Colorado Department of Public Health and Environment and are available by county, and
 - collecting and analyzing hospital and medical insurance data for the four-county region.
 - Self-reported health outcomes and risk factor information was collected for a representative, random sample of residents from throughout Garfield County (by zip code), using a telephone or mail-based household survey.

The health assessment was intentionally broad and comprehensive, in nature, and one might ask why the study looked at disease and disease symptoms that presumably would not be related to exposures from natural gas industry operations. However, many health conditions have symptoms that are similar and/or have multiple causes, and it is a well-established fact that a person’s general health can influence susceptibility to toxins or disease agents. Thus, this study was designed to also look at factors that could contribute to, confound, or exacerbate health conditions or symptoms (i.e., life-style, health insurance, residence, occupational history, concurrent disease, etc.). This comprehensive approach also provides a means of looking at cross-county differences that may or may not be related to natural gas industry activities that occur more intensively in some parts of Garfield County than in other parts.

This study provides a “snapshot in time” of the health of Garfield County residents. It is a population-based, descriptive study, providing correlations and comparisons. The nature of the study and the

available data make it impossible to provide definitive causal relationships between observed health and exposures, particularly at the individual level. It does, however, provide a comprehensive dataset that may be used as a starting place for monitoring health trends or more quickly identifying new trends. It also provides source data for more specific analyses, should other researchers or public health officials wish to delve more deeply into any aspect of the health outcomes described in this report.

Perceptions and Concerns. Health-related perceptions and concerns that were expressed by individuals who participated in public meetings, focus groups, individual interviews or registered complaints with Garfield County Environmental Health could be generally grouped and summarized as follows:

Physical Health Issues/Concerns (Note: The following concerns may or may not have been associated with environmental exposures.)

- Increase in or exacerbations of allergies and asthma and related concerns such as coughing, wheezing, and other respiratory complaints
- Generalized chemical sensitivities
- Fibromyalgia/chronic pain and related concerns such as chronic fatigue and lethargy
- Chronic colds and concern about compromised immune systems
- Headaches, dizziness, burning/itching eyes, nausea/vomiting, sinus problems – most often attributed to odors
- Burning/itching skin
- Mental health issues such as stress, depression, anger, inability to sleep
- Cancer (adrenal cancer, brain tumors, unknown/presumed cancers or “fear of developing cancer”)
- Loss of voice or speech problems
- Trauma/work-related injuries
- Age-related illnesses
- Diabetes
- Obesity
- Perceptions that pre-existing health conditions have been exacerbated; people “feeling worse” than in the past.

Social/Community Issues and Concerns

- Increase in child and spousal abuse; child neglect; stressed family relationships
- Alcohol abuse (especially among high school students)
- Drug abuse (especially methamphetamine use)
- High suicide rate
- Increase in sexually transmitted diseases related to increase in temporary workers
- Lack of health insurance and related concerns such as lack of dental care for children and preventive care
- Lack of access to healthcare and mental health services
- Number of low income families

- Growth issues such as the availability of housing and community services, increase in low-income families, cultural clash (long-time residents, industry workers), traffic, public safety

Environmental Concerns

- Noise
- Odors
- Dust
- “Toxic” chemicals in air and water
- Impacts on domestic animals and wildlife such as reported changes in herd animal reproductive patterns/illnesses and decreases in bird, insect, and deer populations.

Quantitative Health Data. Health outcomes data were collected from a number of sources for Garfield County and comparison counties. The search for health outcomes data was driven by two objectives: 1) to complete a “snapshot in time” picture of the health of Garfield County residents in comparison to the health of residents in the comparison counties, and 2) to obtain statistical data that could be used to respond to the concerns voiced by Garfield County residents during the qualitative data collection process. Thus, to the extent that the data were available, we collected statistical information on the prevalence of conditions such as cancer and asthma and the predominant causes of mortality and morbidity in Garfield County.

The following data were obtained from the Colorado Department of Public Health and Environment (CDPHE; datasets represent the most current data available at the time this report was written):

- Death statistics: rates and leading causes of death (1990-2006)
- Birth defects: types and rates (2000-2006)
- Adolescent health measures (2000-2005)
- Reportable conditions (1998-2006)
- West Nile virus (2002-2007)
- Cancer statistics (1992-2005)
- Behavioral Risk Factor Study Survey (BRFSS) data (2000-2005)
- General health status (physical & mental)
- Diabetes, asthma
- Smoking, weight
- Health insurance
- Injury hospitalization and death: causes and rates (2001-2003)

Hospital and outpatient data were obtained from the following sources:

- Colorado Hospital Association (CHA), Diagnosis Related Group (DRG)-based hospital discharge data (2000 through 1st quarter 2006)
- Emergency room data
- Grand River Medical Center (located in Rifle, CO and serving western Garfield County)
- Valley View Hospital (located in Glenwood Springs and serving eastern Garfield County)
- Rocky Mountain Health Plans (RMHP) – member data for 4 counties
- St. Mary’s Hospital “CareFlight” data

- RMHP hospital inpatient, outpatient and ambulatory member data – 4 county comparison by DRG category

Outcomes Highlights.

Please see the full report for additional measures and comparisons and actual rates. In the following section, references are made to Garfield County disease or condition rates being lower, higher or similar to those of Delta, Mesa and Montrose Counties. For the following reasons, we specifically did not attempt to designate whether or not the rates themselves should be considered “high or low”. First, whether or not a rate is high or low varies with the disease or condition, and has to do with what the expected frequency of that condition would be for a particular population (and hence whether or not the actual frequency is higher or lower than expected). Secondly, whether a rate is high or low is often a matter of individual perception and may depend on why an individual is looking at the rate in question. Thus, for the purposes of this report, the most objective way to report rates is to provide the actual numerical rate (in the full report) and to provide relative comparisons with other communities. Those who use this information may have other measures against which to judge whether or not the rate of a particular disease or condition is acceptably low or too high.

- Cardiovascular disease is the biggest cause of death in all four counties, followed by other heart-related disease and cancer. The rates among the four counties are similar.
 - The age-adjusted, total death rate for Garfield County was comparable to the age-adjusted, total death rate for Delta County, and lower than those for Mesa or Montrose Counties over the period of 1990 – 2006.
 - Garfield County’s crude death rate has been the lowest among the four counties for the past 2 ½ decades.
 - Garfield County’s rate of neonatal and infant deaths was similar to that of Mesa County, and higher than that of Delta and Montrose Counties.
 - Injury death rates (CDPHE data) for 2001-2003 were significantly higher in Garfield County than for the state overall and for Mesa County.
- Birth defect rates in Garfield County were not different from those seen in the comparison counties for the years 2002-2006.
- For selected measures of child and adolescent health, Garfield County had lower rates of teen pregnancy, teen suicide and child abuse than were documented for the other three counties over the time periods surveyed. Child deaths were higher in Garfield County than in the other counties.
- According to the Behavioral Risk Factor Study Survey (BRFSS) data for 2000 – 2005, the percentage of Garfield County residents that have been diagnosed with diabetes or asthma, are smokers or are overweight/obese, and have health insurance is either lower or similar to the percentages in Delta, Mesa and Montrose Counties. (Please see table below.) However, in every case, the confidence limits for Garfield County are very broad, indicating that there are wide variations within the county on these measures. (The 95% confidence limit is the range within which we can be 95% certain that the actual rate for the entire population of the county

– not just the rate for the individuals sampled in the survey – will fall.) This observation is supported by the household survey data. For example, tobacco use is higher among surveyed residents of zip codes 81635, 81650 and 81652 than among residents of zip codes 81601, 81623 and 81635. The percentage of individuals with health insurance is lower among surveyed residents of zip code areas 81623, 81647, 81650 and 81652 and primarily Spanish-speaking households than it is among residents of zip code areas 81601 and 81635.

Topic	Delta County		Garfield County		Mesa County		Montrose County		Colorado	
	%	95% CI*	%	95% CI*	%	95% CI*	%	95% CI*	%	95% CI*
Diagnosed with diabetes	2.8	0.0-5.8	2.6	0.0-5.1	5.4	3.0-7.8	6.4	1.6-11.2	4.6	3.4-5.0
Current smoker	23.9	14.1-33.7	18.7	9.6-27.7	20.7	15.2-26.3	21.8	12.5-31.1	19.9	18.9-20.9
Currently have health insurance	67.6	56.8-78.4	79.2	20.8-87.6	80.1	74.3-85.9	71.3	60.3-82.3	84.4	83.4-85.3
Ever had asthma	17.2	7.9-26.5	16	8.1-23.9	10.6	7.0-14.2	15	5.2-24.7	17.2	7.9-26.5
Overweight BMI** 25.0-29.9	60.7	49.2-72.2	41.8	31.1-52.5	57.3	50.8-63.8	56.3	44.8-67.8	60.7	49.2-72.2
Obese BMI** >30	14.1	5.4-22.7	12.6	4.9-20.2	20.9	15.5-26.3	21.3	12.2-30.3	14.1	5.4-22.7

*Confidence Interval

**Body Mass Index (BMI) is defined as weight in kilograms divided by height in meters squared
Percents are weighted to the total population.

- During the six-year period, 2000-2005, with the exception of 2003, circulation disorders and bone and joint disorders were either the first or second most common reasons for hospitalization (in 2003, birthing and pregnancy disorders was number one, and circulation disorders was third). Respiratory disorders were either the fourth or fifth most common reason for hospitalization in all years; nervous system disorders were ranked either seventh or eighth each year. Digestive disorders ranked third in four out of the six years. Neonatal disorders were sixth in frequency during the entire six-year period.

Injury hospitalization rates obtained from CDPHE for 2001-2003 showed that Garfield County's rates were similar to those for Colorado overall, and lower than those documented for Delta and Montrose Counties. These data correlated with trauma hospitalization data obtained from the Colorado Hospital Association and Rocky Mountain Health Plans. According to CHA and RMHP data, Garfield County's injury hospitalization rates increased for adults (>18 years) after 2005, but still remained lower than the rates for Mesa and Delta Counties. Accident, injury and trauma hospitalization

rates for children (<18 years) residing in Garfield County are the lowest among the four counties.

- The following tables provide a summary of data for hospitalization, outpatient and emergency room visits by diagnosis-related categories for Garfield County, in comparison with Delta, Mesa and Montrose Counties. The data were obtained from the Colorado Hospital Association, Rocky Mountain Health Plans (member data), Grand River Hospital District (located in Rifle; data for residents of Rifle, Parachute/Battlement Mesa and Silt only), and Valley View Hospital (located in Glenwood Springs).

DRG Category	CHA data (2000-1st Q 2007)		RMHP (2000-2007)		Emergency Room	GRHD ER (2004-2006)	Valley View ER* (2004-2006)
	Inpatient Hospital	Outpatient/Ambulatory					
Accident, Injury, Trauma	Garfield County's injury hospitalization rates increased for adults (>18 years) after 2005, but still remained lower than the rates for Mesa and Delta Counties. Accident, injury and trauma hospitalization rates for children (<18 years) residing in Garfield County are the lowest among the four counties.	Garfield County's rates were the lowest among the four counties until 2005 for both adults and children, and remained the lowest for children through 2007.	Same as for inpatient visit rates.	Adult emergency room visits related to accident, injury or trauma increased from 2003 through 2005, then slightly decreased through 2007.	Emergency room visit data for Grand River Hospital District show increasing rates for Silt, Parachute/Battlement Mesa, and Rifle residents for the period 2004-2006.	Adult ER visit rates were stable throughout the period. Rates for children/young adults decreased between 2004 and 2005, then remained stable for the rest of the period.	
Annual Physicals/Well Child Check-ups	Not applicable.	Not applicable.	Garfield County's rates are the lowest among the four counties. Note: These are RMHP data for insured individuals!	Not applicable.	Not applicable.	Not applicable.	
Birth, Pregnancy, Reproductive, and Neonatal	Rates are consistently higher for Garfield County than for Delta, Mesa and Montrose Counties for birthing and pregnancy disorders, but lower for male and female reproductive and neonatal disorders.	Garfield County residents had lower utilization rates than did residents of Delta, Mesa and Montrose Counties. <i>This is likely a reflection of the difference in utilization patterns of insured and uninsured populations.</i>	Same as for inpatient visits.	Same as for inpatient visits.	Data show an increase in birthing and pregnancy-related patient visits for 2005 through 2006 for Silt, Parachute/Battlement Mesa and Rifle residents.	Adult ER visit rates were stable over the period; ER visit rates for this category decreased among young adults. ER visits for conditions in the perinatal period increased through the time period.	

Abbreviations: DRG = Diagnosis-Related Group; CHA = Colorado Hospital Association; RMHP = Rocky Mountain Health Plans; GRHD = Grand River Hospital District. *Data presented for Glenwood Springs zip code areas only.

DRG Category	CHA data (2000-1st Q 2007)		RMHP (2000-2007)		Emergency Room	GRHD ER (2004-2006)	Valley View ER* (2004-2006)
	Inpatient Hospital	Outpatient/Ambulatory	Inpatient Hospital	Outpatient/Ambulatory			
Circulation/Cardiac	Garfield County's rates are the lowest among the four counties.	Garfield County's rates are the lowest among the four counties for both adults and children. Rates show an increasing trend from 2003-2006.	Same as for inpatient visits.	Same as for inpatient visits.	Same as for inpatient visits.	Rates for Silt, Parachute/Battlement Mesa and Rifle residents show an increasing trend for the time period.	Adult ER visits for this category were stable over the period; child/young adult visits decreased.
	Overall, Garfield County hospitalization rates for these disorders are not different than the rates for the other three counties. However, diabetes-related hospitalization rates for both adults and children in Garfield County are the lowest among the four counties.	Rates are consistent with the CHA data for both adults and children.	Same as for ER visits.	ER visit rates for these disorders are generally lower for both adult and child residents of Garfield County than for the other three counties; rates show a slight increasing trend over the time period.	Rates for Silt, Parachute/Battlement Mesa and Rifle residents show an increasing trend for the time period.	Adult ER visits decreased between 2004 and 2005, then remained stable for the remainder of the period. Child/young adult rates increased between 2004 and 2005, then decreased from 2005 through 2006.	
Endocrine/Metabolic							

Abbreviations: DRG = Diagnosis-Related Group; CHA = Colorado Hospital Association; RMHP = Rocky Mountain Health Plans; GRHD = Grand River Hospital District. *Data presented for Glenwood Springs zip code areas only.

DRG Category	CHA data (2000-1st Q 2007)	Inpatient Hospital	RMHP (2000-2007) Outpatient/Ambulatory	Emergency Room	GRHD ER (2004-2006)	Valley View ER* (2004-2006)
<p>Ear, Nose, Throat, Respiratory</p>	<p>Garfield County has the highest rate among the four counties for otitis media, upper respiratory infections, bronchitis, and asthma in children. <i>Asthma hospitalizations have been higher than in either Mesa or Delta Counties since 1993, but were lower than in Montrose County for the period, 1993-2001.</i> Garfield adult hospitalization rates for these conditions were lowest among the counties, as were the rates for COPD and other respiratory infections and inflammations for both adults and children. Exceptions are simple pneumonia and pleurisy in children, which, until 2005, were highest among the four counties.</p>	<p>Hospitalization rates for adult ENT and respiratory conditions were the lowest among the four counties for adults and similar to the other counties for children.</p>	<p>Garfield County outpatient/ambulatory visits for adults were the lowest among the four counties, but highest among the four counties for children. Garfield County rates decreased for both adults and children from 2005 through 2007.</p>	<p>Garfield County ER visit rates for adults were the lowest among the four counties and were stable over the 8-year period. Rates for children in Garfield County increase steadily from 2000-2003, but are similar to those for the other three counties.</p>	<p>ER visit rates for Silt, Parachute/Battlement Mesa, and Rifle residents are variable, but generally increasing over the time period.</p>	<p>Adult visits for otitis media increased between 2004 and 2005, then decreased from 2005 through 2006. Rates for respiratory conditions, in general, and asthma, specifically, were stable throughout the time period. Child/young adult ER visits for otitis media decreased steadily through the time period. Rates for respiratory conditions, overall, were stable, however asthma rates increased.</p>

DRG Category	CHA data (2000-1st Q, 2007)		RMHP (2000-2007)		Emergency Room	GRHD ER (2004-2006)	Valley View ER* (2004-2006)
	Inpatient Hospital	Outpatient/Ambulatory	Inpatient Hospital	Emergency Room			
Eye	No data for this category.	Same as for hospitalization rates.	Garfield County's rates are the lowest among the four counties for both adults and children.	Same as for hospitalization rates.	Same as for hospitalization rates.	Rates for Silt increased sharply between 2004 and 2005; rate increases for Parachute and Rifle were more gradual over the same period. Rifle's rates continued to increase through 2006, while Parachute and Silt's rates decreased.	Adult ER visits were low and stable throughout the period. Child/young adult rates showed a steady decrease over the time period.
Gastrointestinal/Urinary	Garfield County's rates are either the lowest among the four counties, or are similar to those of the other counties for this group of disorders.	Rates are consistent with the CHA data for both adults and children.	Rates are consistent with the CHA data for both adults and children.	ER visit rates for these disorders are lower for Garfield County adults than for the other three counties, and also generally lower for children, but increase over the time period.	ER visit rates for these disorders are lower for Garfield County adults than for the other three counties, and also generally lower for children, but increase over the time period.	Rates for Silt, Parachute/Battlement Mesa and Rifle residents show an increasing trend for the time period.	Adult ER visits for this category were stable throughout the period. Child/young adult visits increased between 2004 and 2005, then decreased between 2005 and 2006.
Infection	No data for this category.	Garfield County outpatient/ambulatory visits for adults were the lowest among the four counties, but highest among the four counties for children during the time period 2000 through 2002.	Garfield County rates are similar to those for the other counties.	ER rates for Garfield County adults were inconsistent, without a sustained trend in either direction, but similar to other counties. Child ER visits for infections were generally higher than other counties.	Rates for infection-related ER visits were variable over the time period, without consistent trends for the communities of Parachute/Battlement Mesa, Silt and Rifle.	Rates for infection-related ER visits were variable over the time period, without consistent trends for the communities of Parachute/Battlement Mesa, Silt and Rifle.	Adult ER visits for infections decreased throughout the period, as did child/young adult visits.

DRG Category	CHA data (2000-1st Q, 2007)		RMHP (2000-2007)		Emergency Room	GRHD ER (2004-2006)	Valley View ER* (2004-2006)
	Inpatient Hospital	Outpatient/Ambulatory	Inpatient Hospital	Emergency Room			
Mental	Garfield County's rates are the lowest among the four counties.	Same as for hospitalization rates.	Garfield County rates are lower than for the other counties and steadily decreasing over the time period.	Same as for hospitalization rates.	Same as for hospitalization rates.	Rates for Rifle and Silt show a gradual increase; rates for Parachute/Battlement Mesa increased steeply between 2005 and 2006.	Overall adult ER visit rates decreased between 2004 and 2005, then increased to 2004 levels between 2005 and 2006. Drug/alcohol-related visits showed a steady increase over the period. The same pattern was seen for children and young adults.
Musculoskeletal	Garfield County's rates are the lowest among the four counties.	Same as for inpatient visits.	Rates are consistent with the CHA data for both adults and children.	Same as for inpatient visits.	Same as for inpatient visits.	No data for this category.	Adult ER visits were stable over the time period, as were child/young adult visits.
Nervous System	Overall, Garfield hospitalization rates for these disorders are lower than for the other counties. For the subcategory of seizure and headache, rates for children in Garfield County have increased since 2004, while decreasing in adults.	Rates are consistent with the CHA data for both adults and children.	Rates are consistent with the CHA data for both adults and children.	Rates are consistent with the CHA data for both adults and children.	Garfield County ER visit rates, overall, were the lowest among the four counties.	Rates for Silt, Parachute/Battlement Mesa and Rifle residents show an increasing trend for the time period.	Adult ER visits, including those related to headaches or migraines, were stable over the period. Child/young adult visits overall increased between 2004 and 2005, then decreased through 2006. Visits related to headaches or migraines increased.

Abbreviations: DRG = Diagnosis-Related Group; CHA = Colorado Hospital Association; RMHP = Rocky Mountain Health Plans; GRHD = Grand River Hospital District. *Data presented for Glenwood Springs zip code areas only.

DRG Category	CHA data (2000-1st Q 2007)	RMHP (2000-2007) Inpatient Hospital	Outpatient/Ambulatory	Emergency Room	GRHD ER (2004-2006)	Valley View ER* (2004-2006)
Pancreas/Liver	Rates for these conditions for Delta County were consistently the highest among the four counties. Garfield County's rates were not different from those of Mesa and Montrose Counties.	No data for this category.	No data for this category.	No data for this category.	No data for this category.	Included with "Gastrointestinal/urinary" category.
Red Cell/Clotting	Garfield County's rates steadily decreased from 2001 through 2006.	No data for this category.	No data for this category.	No data for this category.	No data for this category.	Adult ER rates increased between 2004 and 2005. Child/young adult rates were stable through 2005, then decreased through 2006.
Skin/Allergy	Rates for these conditions for Delta County were consistently the highest among the four counties. Garfield County's rates were not different from those of Mesa and Montrose Counties.	Garfield County's rates are the lowest among the counties, showing periods of moderate rate decrease (2001-2003) and increase (2003-2005).	Garfield County's rates are the lowest among the four counties, increasing slightly from 2003 to 2004, then decreasing from 2005 through 2007.	Garfield rates are lowest among the counties, and were generally stable throughout the 8-year period, except for an increase between 2003 and 2004, decreasing to previous rates in 2006. (Rates for children in Garfield County decreased steadily from 2005 through 2007.)	Rates for Silt, Parachute/Battlement Mesa and Rifle residents show an increasing trend for the time period.	Adult ER rates were stable. Child/young adult rates decreased through the period.

Cancer

- One of the difficulties of observing relatively recent trends in cancer incidence statistics and trying to draw conclusions about possible changes in risk factors is that, with respect to carcinogenic exposures, these trends reflect events that happened 10- 20 years ago or are cumulative over a lifetime. Generally speaking, the appearance of clinical cancer has a “lag” time of up to two decades following initiation of carcinogenesis. (Childhood cancers and some rare cancers are exceptions.) Thus, with the exception of changes in cancer screening practices that often artifactually inflate cancer rates, short-term trends may not reflect changes in the potential for exposure to carcinogenic materials.
- County-specific cancer rates for Delta, Garfield, Mesa and Montrose counties for the time period of 1992 through 2005 show that incidence rates for all cancers have changed little over this period, although cancer rates in males dropped slightly for Delta, Garfield, and Montrose counties for the most recent time period for which data are available (2003-2005). There is relatively little difference among the counties for either male or female cancer incidence rates across the designated time periods.
- When compared to the state cancer rates, the following observations could be made for Garfield County:
 - The incidence rate of all cancers combined was significantly higher than the state rate for males from 1992 through 2000 and for females from 1992 through 1998.
 - The incidence rate of all cancers combined was significantly lower than the state rate for females from 1999 through 2000.
 - The incidence rate of prostate cancer was significantly higher than the state rate from 1992 through 2000.
 - Incidence rates for colorectal cancer, lung cancer, melanoma, bladder cancer, leukemias, and thyroid cancer in both males and females, and for breast and cervical cancer in females, did not differ significantly from the state rates for the period 1992 through 2005.
- For comparison, the following observations were made for Mesa County:
 - The incidence rate of all cancers combined was significantly higher than the state rate for males from 1992 through 2005.
 - The incidence rate of prostate cancer was significantly higher than the state rate from 1999 through 2005, but was significantly lower than the state rate from 1992 through 1998.
 - The incidence rate of lung cancer was significantly higher than the state rate from 1992 through 2000 and from 2003 through 2005 for both males and females.

- The incidence rate of melanoma in males was significantly higher than the state rate from 1999 through 2000.
- The incidence rate of bladder cancer in females was significantly higher than the state rate from 2001 through 2002.
- The incidence of thyroid cancer in females was significantly lower than the state rate from 2003 through 2005.
- Incidence rates for colorectal cancer, and leukemias in both males and females, and for melanoma, thyroid cancer, breast cancer and cervical cancer in females, did not differ significantly from the state rates for the period 1992 through 2005.

Sexually Transmitted Diseases (STDs)

Of the conditions that are reportable to the state health department, other than cancer, a recent trend in the frequency of STD diagnoses is worth noting:

- For the time period, 2003 through 2007, the rate of reported cases of Chlamydia in both Garfield and Mesa Counties has steadily increased. It is not clear, at this time, whether this rate increase is due to an actual increase in disease or is an artifact of changes in screening patterns in the two counties. Overall, Garfield County's rates are lower than those for Mesa County and the state, but higher than those for Delta and Montrose Counties. Both Delta and Montrose Counties show an increase in reported cases for 2004-2005, but then the rates are flat (Delta) or decrease (Montrose) from 2005 through 2007.
- Similarly, the rate of reported cases of Gonorrhea in Garfield and Mesa Counties steadily increased from 2003 through 2007. Garfield County's rates are again lower than those for both Mesa County and the state, but higher than those for Delta and Montrose Counties. Delta County's Gonorrhea cases showed the same pattern as for Chlamydia; Montrose County's Gonorrhea cases increased slightly over the period 2004 through 2007.
- Garfield County had the highest rate of reported HIV cases among the four counties for the years 2000, 2001, 2003, and 2005. These rates were higher than the state rate for the years 2001 and 2003. (There were no cases reported in 2002, 2006, or 2007.)
- Garfield County had the highest rate of reported AIDS cases among the four counties for the years 2000, 2003, 2004, and 2005. (There were no cases reported in 2001, 2002, or 2006.)

Self-Reported Health Status: Household Survey. A targeted health survey was administered to Garfield County residents by trained interviewers. The in-home surveys captured information about the general health and health risk factors of residents, as well as information about specific health conditions that were identified as priority concerns during focus group discussions. This information was intended to provide a more objective measure of the health status of community residents, and a means of conducting *within* County comparisons.

We collected data on 1,048 individuals, representing ~2% of the households in Garfield County that have listed telephone numbers. This number included 49 interviews, conducted in Spanish, of primarily Spanish-speaking households (representing 195 individuals). Respondents were asked to provide information for every individual living in the household. Thus, we were able to achieve a population sample that is representative of the gender, age, and ethnicity demographics of Garfield County, and approximated the occupational, education, and household income diversity that exists in the county. Respondent households represented each of the zip code areas within Garfield County, with a low of 1.25% and a high of 2.52% of households with listed phone numbers in zip codes 81601 and 81652, respectively, completing the survey. (Zip code areas 81601 and 81623 are the least affected by natural gas drilling and production activities; zip code areas 81635, 81647, 81650, and 81652 are most affected by these industry activities.) The majority of those responding to the survey had lived in Garfield County for greater than 5 years.

Household Survey Outcomes Highlights (Please see the full report for additional measures and comparisons):

- Greater than 80% of individuals from every zip code area in Garfield County rated their current health as either excellent or good, and less than 10% of individuals in every zip code area felt that their current health is somewhat worse or much worse than it was one year ago.
- Approximately 12% of individuals, county-wide, reported that they had suffered an illness or injury during the past year that had affected their health for greater than 5 days.
- Approximately 8% of individuals, county-wide, reported suffering from depression.
- 20% of individuals reported suffering from a variety of allergies, including hay fever.
- 8% of individuals suffer from frequent headaches or migraines; a zip code comparison shows that the lowest frequency of headache sufferers live in zip code 81623 (4%), while the highest frequency was reported from zip codes 81635 and 81647 (8.3% each).
- 3.8% of individuals report living with diabetes and its side effects such as kidney problems, loss of feeling or pain in hands and feet, and eye problems. There was no difference among the zip code areas for frequency of diabetes.

- 24% of individuals have coronary disease, a category that includes heart attack or heart surgery, high blood pressure, stroke and angina. There was no difference among the zip code areas for frequency of coronary disease.
- 10% or less of children born in any zip code area of Garfield County were reported to have developed health or developmental problems within 5 years of their birth.
- 5% of individuals, county-wide, reported having some kind of cancer during their lifetime.
 - ~2X as many individuals residing in zip code area 81635 reported having cancer than was reported for the county overall. *It is important to note, however, that the average age of the respondents from this zip code area was considerably older than for the other zip code areas.*
 - 53.3% of the reported cancers were diagnosed in individuals who were 55 years or older; There were NO cancers reported in individuals under age 25.
 - The most frequently reported cancers were female breast cancer (20.7%), non-melanoma skin cancers (26.4%), prostate cancer (15.1%), cervical cancer (9.4%), and colon cancer (7.5%). Malignant melanoma and lymphoma each accounted for 3.8% of the reported cancers. Uterine, thyroid, liver, kidney, and bladder cancers, along with leukemia, glandular carcinoma, made up the remainder of the cancers reported (1.9% each).
- Because respiratory complaints were expressed so frequently in interviews and focus groups, we asked a number of specific questions about respiratory conditions and contributing factors such as smoking.
 - 6.5% of individuals, county-wide, reported having a diagnosis of asthma; the highest frequency of individuals with asthma was in zip code area 81647 (8.3%), while the lowest frequency of individuals with asthma was in zip code area 81652 (4.7%). Both zip code areas have significant natural gas industry activity.
 - Similar to what was observed with other respiratory conditions such as Chronic Obstructive Pulmonary Disease (COPD), emphysema and other lung or breathing problems, the zip code area having the highest frequency of these conditions was among those most highly impacted by natural gas industry activity, but the lowest or next to lowest frequency was also found among these impacted zip code areas.
 - Age and smoking are factors that clearly influence the incidence of these conditions. 27% of county residents, overall, reported having smoked at least 100 cigarettes during their lifetime; 60% of these have quit smoking. 85% of respondents reported that smoking is NOT allowed within the home.

Occupation and Disease

- Responses to questions about occupational history (current and longest job titles and industry affiliations) allowed correlations with diseases and symptoms reported by survey respondents.
- It is important to note that this study was not designed as an occupational health study, and thus, no conclusions may be drawn regarding occupational exposures and disease outcomes. The numbers of individuals within any occupational category that report having a particular disease or condition are too low for statistical significance. However, the following observations may be made:
 - Individuals who reported that their current and/or longest occupation was in the professional and related services industries (e.g., healthcare providers, attorneys, etc.), personal services occupations (e.g., housekeepers, hair stylists, etc.), construction industries or transportation (including truck drivers), communications and public utilities industries were most likely to have reported having respiratory conditions; neurological symptoms such as dizziness, numbness, weakness; skin problems; and frequent headaches/migraines.
 - Those individuals who refused to answer questions about their occupation and/or industry affiliation were most likely to have reported having frequent headaches/migraines; neurological symptoms such as dizziness, numbness, weakness; anemia; seizures; skin problems; and cancer (but no bladder, kidney, liver, lymphoma or thyroid cancers or leukemia).

Relationships Between Health and Environmental Exposures: Household Member Concern

A series of questions regarding perceptions of risk related to home and outside environmental exposures and their relationship to health outcomes were asked at the end of the survey. These questions were intended to serve as measures of concern and perceptions among a randomly selected population within Garfield County (as opposed to the more self-selected population that provided comments during focus groups, interviews, and public meetings), and to provide some measure of the potential bias with which survey respondents might have responded to questions about their health.

- When asked whether or not they are concerned that their home drinking water source was related to any of their health problems, between 5.5 and 17% of individuals who live in areas with high natural gas industry activity (zip code areas 81635, 81647, 81650, and 81652) responded that they are concerned, while only 3-5% of individuals who live in the areas least impacted by natural gas industry activity (zip code areas 81601 and 81623) responded in the same manner.
- When asked whether or not they are concerned that their health problems may be related to chemicals in or near their homes, between 6 and 16% of individuals who live in areas with high natural gas industry activity (zip code areas 81635, 81647, 81650, and 81652) responded that they are concerned; between 1.4 and 7% of individuals who live

in the areas least impacted by natural gas industry activity (zip code areas 81601 and 81623) responded in the same manner.

- When asked if they are concerned that either environmental or chemical hazards in their neighborhoods may be related to health problems,
 - Between 24 and 38% of individuals residing in zip code areas 81635, 81647, 81650, and 81652 responded that they are not worried at all. Between 76 and 62% of individuals in these zip code areas responded that they are “a little worried”, “very much worried”, or “don’t know/not sure”.
 - Between 56 and 43% of individuals residing in zip code areas 81601 and 81623 responded that they are not worried at all. Between 44 and 57% of individuals in these zip code areas responded that they are “a little worried”, “very much worried”, or “don’t know/not sure”.
 - County-wide, individuals who have a high school education or less are slightly less worried about the relationship between their health and environmental or chemical hazards in their neighborhoods.
- When asked specifically whether they are concerned that natural gas industry activities may be related to health problems,
 - Between 69 and 92% of individuals residing in zip code areas 81601 and 81623 responded that they are not concern. Between 8 and 31% of individuals in these zip code areas responded either that they are concerned or that they “don’t know or are not sure”.
 - 90% of individuals residing in zip code areas 81601 and 81623 responded that they are not worried at all. 10% of individuals in these zip code areas responded that they either that they are concerned or that they “don’t know or are not sure”.
 - There was essentially no difference related to education between individuals who responded that they are concerned about health-related impacts of the natural gas industry and those who are not concerned or are not sure.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions.

- At the present time – based on our data sources – there is not a health crisis in Garfield County, but there are some health trends that should be monitored. We cannot say conclusively that any of these health trends are directly related to the presence of natural gas industry activities or to other factors.
- Accident, injury and trauma hospitalization and emergency room visits have been increasing, particularly for adults.
- Child (1-14 years) deaths in Garfield County for 2001-2005 are considerably higher than the state's 2010 goal (35.5/100,000 versus 19/100,000, respectively) and higher than the rates for Mesa and Montrose Counties.
- Although circulation disorders and cardiac disease rates are lower in Garfield County than in the other three counties studied, these conditions have been among the most common reasons for hospitalization, and rates for inpatient, outpatient and emergency room visits appear to be increasing.
- Hospitalization rates for birthing, pregnancy and gynecological disorders are consistently higher for Garfield County than for the other counties studied, and emergency room visits for these disorders appear to be increasing, at least among Silt, Parachute/Battlement Mesa and Rifle residents.
- Upper respiratory infections, bronchitis, asthma and otitis media rates in children, in particular, have generally been higher for Garfield County than in the other counties studied. Emergency room visits for these conditions have been increasing.
- Mental health-related emergency room visits for residents of Silt, Parachute/Battlement Mesa and Rifle increased between 2005 and 2006.
- Hospitalization rates for seizure and headache in children in Garfield County showed an increasing trend between 2004 and 2007. Emergency room visits for the general category of nervous system disorders showed an increasing trend for residents of Parachute/Battlement Mesa and Silt for the 2004-2006 time period. However, it is important to note, that overall, rates for nervous system disorders in Garfield County are as low as or lower than those same rates in Delta, Mesa and Montrose Counties.
- Although the actual number of cases is relatively low, the frequency of diagnosed and reported sexually transmitted diseases has increased steadily in Garfield County since 2003.

- At this time, there are no cancer trends in Garfield County that are of notable concern. However, because of the lag period between exposure and cancer development, cancer rates should be reviewed on a periodic basis.
- Risk modeling indicated that there are industry factors that could present a public health risk – use of best practices can reduce that risk.

Recommendations

- Establish a medical monitoring system – especially through primary care networks – to identify any changes in baseline data or trends and/or anomalies in medical practices.
- Conduct a thorough study of air emissions during drilling, including enough sites to cover the range of drilling approaches.
 - Collect 24-hour samples daily around the perimeter of the drill pad to achieve continuous monitoring during several cycles of well installation.
 - Monitor meteorological conditions.
- Identify the components of hydraulic fracturing fluids.
 - Would allow open evaluation of degree of threat.
 - Would improve public acceptance of natural gas operations.
- Inspect surface soils at completion of drilling operations.
 - Minimize possible exposure of landowners to residual soil contamination.
 - Sample and analyze areas suspected to be contaminated.
 - Clean up areas exceeding action levels.
- Use “green completions” and applicable best management practices, including locating drilling and production facility operations far enough from public buildings and residences to reduce the risk of exposure to air toxics, such as benzene, toluene, and xylenes.
- Establish a monitoring program for private wells
 - Provides the most direct way to assess contamination of drinking water resources
 - Analyze for methane, benzene and other volatile organic compounds, and selected components of hydraulic fracturing fluids having the greatest potential to affect human health