

**THE SOCIAL AND ECONOMIC IMPACT
OF INJURY AND ILLNESS
AMONG MAINTENANCE-OF-WAY EMPLOYEES**

**FOR BROTHERHOOD OF MAINTENANCE OF WAY EMPLOYEES DIVISION,
INTERNATIONAL BROTHERHOOD OF TEAMSTERS**

BY

DR. RUTH RUTTENBERG

WITH

DR. KATHY MASON, DR. ESTYE FENTON, KAREN LANE,

MARIA OBANDO, ELI FENTON

JULY 2018

DEDICATION

**TO THE MEN AND WOMEN
WHO BUILD AND MAINTAIN
OUR RAILROAD TRACK AND BRIDGE SYSTEM
AND WHO, IN TOO MANY INSTANCES,
HAVE GIVEN THEIR LIVES AND HEALTH IN THE PROCESS**

ACKNOWLEDGMENTS

Thanks to the thousands of BMWED members, current and retired, who responded to the survey as well as all those who participated in interviews or were members of focus groups.

Thanks to BMWED President Freddie Simpson and the National Division officers, who had the foresight and wisdom to support this important study. And thanks to the many General Chairpersons, System Officers, Local Officers, Internal Organizers, Communication Action Team (CAT) volunteers, and union staff for their tireless work answering questions and encouraging voluntary membership participation in the study.

Special thanks to Rick Inclima, now retired BMWED Director of Safety and Education, for his dedication and hard work on this project; the BMWED Occupational Research Committee for their guidance and counsel; and to Information Systems Director Chris Leidy and the IT staff in the union's IT department. Thanks also to Roy Morrison, current Director of Safety for the BMWED, and Communications Director Clark Ballew and staff for their substantial efforts and support.

Thanks to the skilled academic team that worked on and helped author this report –Dr. Kathy Mason, Dr. Estye Fenton, Karen Lane, Maria Obando, and Eli Fenton. And, thanks to Chandra Blackmer, Gabriella Zeichner, and Yasi Zeichner for their work to input data on hundreds of written surveys.

Thanks also to Dr. Nicholas Ashford, MIT, and Dr. Les Boden, Boston University, for their peer review of this document. Thanks to the other research teams involved in this overall project.

**THE SOCIAL AND ECONOMIC IMPACT
OF INJURY AND ILLNESS
AMONG MAINTENANCE-OF-WAY EMPLOYEES**

TABLE OF CONTENTS

PREFACE.....	i
INTRODUCTION.....	1
A. Safety and Health Challenges for the Railroads and Workers Who Perform Maintenance-of-Way Work.	2
B. The Railroad Industry	2
C. The Brotherhood of Maintenance of Way Employees Division of The International Brotherhood of Teamsters.....	3
D. Context of Social and Economic Impact within Overall BMWED Health and Safety Study	5
I. HEALTH AND SAFETY RISKS TO MAINTENANCE-OF-WAY WORKERS.....	5
A. Overview of Information Gathered from Surveys, Interviews, and Focus Groups with BMWED Members	6
1. Out-of-Pocket Expenses	7
2. Caretakers and Health Aides: Out-of-Pocket Expenses and Lost Wages.....	7
3. Lost Work Due to Work-Related Injuries and Illnesses	7
4. Pain	8
5. Working shorthanded.....	8
6. Perception of Shortened Life	8
7. Personal Protective Equipment (PPE)	8
8. Good Training Would Save Money.....	8
9. Injury Reporting.....	9
10. Problems with Scheduling	9
11. Weed Spraying.....	9
B. Economic and Social Impact of Injury and Illness	9
1. Direct Medical Costs.....	10
2. Indirect Costs	11
a. Lost Productivity.....	11
b. Absenteeism	11
c. Presenteeism	12
d. Impacts on Families	12
e. Impacts on Quality of Life.....	17

II. ECONOMIC AND SOCIAL IMPACTS OF CHRONIC ILLNESS AND INJURIES IN GENERAL.....	18
A. Costs to Third Parties Have Been Underestimated.....	18
B. Potential Cost in Life Years Lost for Those Who Live Rurally.	19
C. Cost in Caregiving	19
D. Cost to the Railroads.....	21
III.FOCUS ON FIVE FREQUENT OCCUPATIONAL DISEASES AND MUSCULO-SKELETAL DISORDERS OF MAINTENANCE-OF-WAY WORKERS	22
A. Three Major Chronic Diseases.....	23
1. Chronic Obstructive Pulmonary Disease (COPD).....	26
a. Description and Progression of COPD	26
b. Causes of COPD	27
c. Economic and Social Impacts of COPD.....	28
d. Costs of COPD to the BMWED Membership and to Individuals	32
2. Cancerous Chronic Kidney Disease.....	35
a. Some Causes of Chronic Non-Cancerous Kidney Disease.....	36
b. Economic and Social Impact of Chronic Non-Cancerous Kidney Disease.....	38
c. Costs of Chronic Non-Cancerous Kidney Disease to the BMWED Membership and to Individuals.....	40
3. Cancer	42
a. Economic and Social Impacts of Cancer	44
b. Costs of Cancer to the BMWED Membership and to Individuals.....	49
B. Two Major Musculoskeletal Disorders (MSDS)	51
1. Lower Back Pain and Related Disability	54
a. Description and Progression of Lower Back Pain (LBP) and Disability.....	54
b. Causes of Lower Back Pain and Disability.....	55
c. Economic and Social Impact of Lower Back Pain and Disability.....	56
d. Costs of Lower Back Pain to the BMWED Membership and to Individuals	57
2. Carpal Tunnel Syndrome	60
a. Description and Progression of Carpal Tunnel Syndrome	61
b. Causes of Carpal Tunnel Syndrome	61
c. Economic and Social Impacts of Carpal Tunnel Syndrome	62
d. Costs of Carpal Tunnel Syndrome to the BMWED Membership and to Individuals.....	63

C.	Costs Associated with Five Occupational Health Issues	64
D.	Other Health Issues Facing Maintenance-of-Way Workers	66
IV. SUMMARY AND CONCLUSIONS		68

TABLES:

Table 1:	Distribution of Total Incremental Costs of Medical Expenditures by Sources of Payment
Table 2:	Estimated Source of Payment of Injury Costs by Cost Category, Percent of Total Cost
Table 3:	Sales Required to Pay for Direct and Indirect Costs for Five Leading Occupational Illnesses and Musculoskeletal Disorders
Table 4:	Estimated Costs of COPD to Individuals and to the BMWED Community
Table 5:	Estimated Costs of CKD to Individuals and to the BMWED Community
Table 6:	Annualized Mean Net Costs of Care for Men with Cancer - Initial Treatment, Continuing Treatment, and Last Year of Life, 2010 and 2016 Dollars
Table 7:	Estimated Costs of Cancer to Individuals and to the BMWED Community
Table 8:	Estimated Costs of Lower Back Problems to Individuals and to the BMWED Community
Table 9:	Estimated Costs of Carpal Tunnel Syndrome to Individuals and to the BMWED Community
Table 10:	Estimated Costs of Excess Individual Cases of 5 Major Health Issues Affecting Maintenance-of-Way Workers
Table 11:	Estimated Costs to the BMWED Community for 5 Major Health Issues Affecting Maintenance-of-Way Workers (In millions of 2016 dollars)

BIBLIOGRAPHY

APPENDICES

Appendix I:	Methodology
Appendix II:	Survey Protocol
Appendix III:	Map of Zip Codes from which BMWED Members Responded to the Survey
Appendix IV:	Employment Benefits Available to Rail Workers

Appendix V: Tables of Survey Results Associated with Social and Economic Costs to Workers and Their Families

Appendix VI: Underreporting of Injuries and Illnesses

Appendix VII: Questionnaire Protocol for Non-Responders to On-Line Survey

THE SOCIAL AND ECONOMIC IMPACT OF INJURY AND ILLNESS AMONG MAINTENANCE-OF-WAY EMPLOYEES

PREFACE

*“I feel like I got old awful fast working on the railroad
and now I have millions of aches and pains.”*

“My body is just worn out due to the type of work I did.”ⁱ

Tragically, every year maintenance-of-way workers lose their lives in roadway track accidents.ⁱⁱ While these incidents are immediately visible, there are hundreds of other maintenance-of-way (MOW) workers who lose their lives and well-being every year due to workplace illnesses and a wide-range of injuries. What follows is a study of these individuals – their illnesses and injuries and the suffering and burdens they endure. While the health impact is clearly the most serious, the focus here is on the social and economic impacts of all these events. When a worker becomes sick or is injured, beyond pain and suffering, there are often financial burdens that affect families, railroad companies, insurers, communities, and taxpayers as well as the injured worker.

The overall study, of which this is just one of three parts,ⁱⁱⁱ probes the health and safety risks facing railroad track workers, and the impact of resulting illnesses and injuries. This is probably the most comprehensive study of this type that has ever been conducted even though it is common knowledge that there are many risks on the tracks and along the right-of-way. The overall study documents the risks faced by BMWED members and profiles their health status. It also assesses the epidemiological, ergonomic and physical hazards, and social and economic realities associated with their workplace risks. The entire membership of BMWED, both active workers and retirees, was invited to participate in the research survey. (See Appendix I for description of Methodology and Appendix II for a copy of survey.) Of approximately 39,000 BMWED members invited to participate (35,000 current and 4,000 retired), approximately 4,800 members responded, coming from all 48 continental states (See map in Appendix III) and all seven Class I freight railroads as well as a number of passenger/commuter and regional/short-line railroads. They returned the survey on-line or in writing, or orally over the telephone. In addition, for this social and economic

ⁱ Comments from BMWED surveys and interviews.

ⁱⁱ There are approximately three fatal “roadway worker” accidents a year, usually being struck by a train or other on-track equipment. “Fatality Analysis of Maintenance of Way Employees and Signalmen (FAMES): 25 years of data shows 4th quarter spike in fatal roadway incidents,” December 3, 2015, <https://www.bmwe.org/secondary.aspx?id=104>, accessed October 27, 2016; Brotherhood of Maintenance-of-Way Employes, “Cowboy” Video: “A Brother’s Story, Dave ‘Cowboy’ Stevens,” <http://www.bmwe.org>, accessed January 2017.

ⁱⁱⁱ The full research efforts include this social and economic impact study, a mortality study, and a health study of ergonomic and physical hazards.

impact study, an additional 155 in-depth interviews, and two focus groups provided additional worker input.

The work that follows finds that the burden of disease and injury borne by tens of thousands of MOW workers, leaves these workers as well as their families, railroad companies, insurers, taxpayers, and society in general to face costs of more than **\$1.7 billion to \$2.3 billion** in direct medical costs and even more in indirect costs (documented in detail in this study).^{iv}

^{iv} These costs are societal and have not been allocated to individual parties or groups of parties because of the complexities of third-party payment and differences across diseases and geography. This is especially the case of allocation of burden among employers, private insurers, workers compensation, and Federal Employers Liability Act (FELA)-sanctioned legal compensation.

THE SOCIAL AND ECONOMIC IMPACT OF INJURY AND ILLNESS AMONG MAINTENANCE-OF-WAY EMPLOYEES

“Anyone who thinks that working for the railroad is easy has never worked for the railroad. Also...whoever thinks that railroaders don’t get hurt to the point they are permanently disabled and can’t perform their tasks or job duties...has never worked for the railroad.”

“The railroad has been the greatest blessing and the biggest curse for me and my family.”¹

INTRODUCTION

Maintenance-of-way workers face significant risks to their health and safety on a daily basis. Maintaining the track is one of the most dangerous jobs facing any railroad workers.² Chemicals drip from tank cars onto the track. MOW workers are exposed to herbicides and pesticides sprayed along the track to keep the right-of-way clear, and they are also exposed to silica dust (mostly from track ballast), creosote (wood preservative used on wood railroad ties), diesel fumes, solvents and asbestos. Maintenance-of-way workers bend, twist, and do heavy lifting on a daily basis, and this puts them at high risk of injuring their necks, shoulders, knees, backs, hips, elbows, and wrists. They face a host of ergonomic risks from their use of high vibration tools and equipment. They face high noise levels and uneven surfaces walking on ballast. Many suffer from significant back pain. Beyond this toll in risk to life and health, is billions of dollars in health-related costs.

This study focuses on the economic and social impact of just five serious health issues facing many maintenance-of-way workers: chronic obstructive pulmonary disease (COPD), chronic non-cancerous kidney disease (CKD), cancer, lower back problems, and carpal tunnel syndrome (CTS). From these five infirmities alone, the burden borne by just the 35,000 active BMWED workers (not retirees or non-BMWED MOW workers), leaves these workers -- as well as their families, railroad companies, insurers, taxpayers, and society at-large – with estimated costs of more than **\$1.7 billion to \$2.3 billion**, numbers developed and documented in this study.³ When extrapolated broadly to include all workers performing MOW work nationwide (e.g., non-BMWED MOW workers, transit, subway, shortline, and contractor workers) the cost would be significantly higher. Those familiar with the railroad industry estimate that there are probably another 35,000 non-BMWED workers engaged in MOW work nationwide. If so, then the \$1.7 billion to \$2.3 billion could easily rise to \$3.4 billion to \$4.6 billion dollars.

¹ Comments from BMWED surveys and interviews.

² Van Zante-de Fokkert, J. et al., “The Netherlands Schedules Track Maintenance to Improve Track Workers’ Safety,” *Interfaces*, Vol 37, No 2, March-April 2007, p. 133.

³ These costs are societal and have not been allocated to individual parties or groups of parties because of the complexities of third-party payment and differences across disease and geography. This is especially the case of allocation of burden among employers, private insurers, workers compensation, and Federal Employers Liability Act (FELA)-sanctioned legal compensation.

A. SAFETY AND HEALTH CHALLENGES FOR THE RAILROADS AND WORKERS WHO PERFORM MAINTENANCE-OF-WAY WORK

This study of the social and economic impact of workplace injury and illness on BMWED members is one of three parts in an overall health and safety study. The other two studies – one epidemiological and a second on ergonomic and physical hazard issues – complement this work. This portion of the research begins by assessing the degree to which BMWED-represented employees face significant risk of disease, injury, and death from their daily work. While reported incidents to the Federal Railroad Administration (FRA) show excess death and injury to BMWED workers compared to all other railroad employees, publicly available FRA data are incomplete when it comes to actual on-the-job injury, occupational illnesses, and subsequent death.

Employee deaths and injuries across the rail industry, reported annually to the Federal Railroad Administration, rose to 4,466 in 2014.⁴ Maintenance-of-way and structures employees accounted for 1,123, or 25.1 percent, of those railroad deaths and injuries,⁵ yet these employees are but 35,000, or 21.1 percent, of the total railroad workforce of over 166,000.⁶ Of all 4,466 incidents, FRA counted only 34 as involving occupational illness. The accuracy of these low rates of occupational illness and death from illness are challenged by the findings of this report.

Occupational injuries, illnesses, and deaths across the U.S. have widespread effects on the workforce. According to the National Safety Council, more than 65 percent of lost work time is from occupational injuries, 65 million of 99 million lost work days in 2014. In addition, more than twice as many people in the U.S. are injured in workplace incidents than are injured in motor vehicle accidents – 4.7 million vs. 2.1 million. The transportation sector (including railroads) is superseded only by agriculture and mining in the number of occupational deaths in the U.S. – more than six times the rate of manufacturing.⁷

B. THE RAILROAD INDUSTRY

In 2014 there were 30.2 million car-loads of material shipped by rail in the U.S. There were 180 million tons of chemicals and allied products transported in 2014 – over 10 percent of the total. There were also nearly 640 million tons of coal, over 90 million tons of crude and refined petroleum, natural gas and coke transported, and nearly 160 million tons of non-metallic minerals. Rail shipped over 95 million tons of metallic ores, waste, and scrap material.⁸

⁴ U.S. Department of Transportation, Federal Railroad Administration, “Casualties (Deaths and Injuries) to Employees on Duty (By Calendar Year, Jan-Dec), All Employees” <http://safetydata.fra.dot.gov/officeofsafety/publicsite/Query/castally1.aspx>, accessed November 14, 2015. [As of November 2017, this document is no longer on the web. Subsequent statistics no longer provide parallel data.]

⁵ Ibid.

⁶ Association of America Railroads, “Class I Railroad Statistics,” <https://www.aar.org/Documents/Railroad-Statistics.pdf>, accessed May 3, 2016.

⁷ National Safety Council, Injury Facts (2014 data), 2016, pp. 59, 62, 63.

⁸ Association of America Railroads, “Class I Railroad Statistics”...

In 2016, Class I railroads alone had annual carrier operating revenue streams of \$250 billion or more.⁹ These seven Class I freight railroad companies are:

- BNSF Railway Company
- Canadian National Railway, Grand Trunk Corporation
- Canadian Pacific, Soo Line Corporation
- CSX Transportation
- Kansas City Southern Railway Company
- Norfolk Southern
- Union Pacific Railroad Company.

The Class I railroads employ most of the 166,000+ railroad employees,¹⁰ with Class I employment as of March 2016 at 149,000.¹¹ At year-end 2013, these seven railroads had over \$192 billion in assets, up over 8 percent from 2012.¹² Revenue per ton mile was over 4 cents, up over 2.5 percent from 2012.¹³ What were the profit margins? Estimates in 2015, found net profit margins for railroad companies consistently in the double-digits, usually 15 percent to 20 percent, with the industry-wide average operating margin around 30 percent.¹⁴

C. **THE BROTHERHOOD OF MAINTENANCE-OF-WAY EMPLOYEES DIVISION OF THE INTERNATIONAL BROTHERHOOD OF TEAMSTERS**

The Brotherhood of Maintenance of Way Employees Division (BMWED) of the International Brotherhood of Teamsters is a national union representing the workers who build and maintain the tracks, bridges, buildings, and related infrastructure on all Class 1 railroads in the United States. Railroad track employees work in local, regional, and system-wide road gang crews on 300,000 miles of railroad track across the United States.¹⁵ The union was originally founded as a benevolent society to provide aid and comfort to widows and orphans of MOW employees killed and injured on the job. The union was chartered in Alabama in July 1887. Employment of railroad maintenance-of-way workers in the U.S. peaked in 1927 at over 416,000. By the mid 1950's it

⁹ Statista.com, "Leading North American railroads in 2016, based on operating revenue," <https://www.statista.com/statistics/271613/leading-north-american-railroad-companies-based-on-revenue/>, accessed December 7, 2017.

¹⁰ Association of American Railroads, "Class I Railroad Statistics" ...

¹¹ U.S. Surface Transportation Board, reported in "Class I railroad employment up slightly in March," in *Trains Industry Newsletter*, May 2, 2017, <http://trn.trainers.com/news/news-wire/2017/05/02-class-i-railroad-employment-up-slightly-in-March#.WjWcce3HRWC.emal>, accessed November 22, 2017.

¹² Association of American Railroads, "Railroad Facts," 2014 Edition, 2014, p. 9.

¹³ Ibid.

¹⁴ Maverick, J.B., "What is the average profit margin for a company in the railroads Sector?", February 11, 2015, <http://www.investopedia.com/ask/answers/021115/what-average-profit-margin-comapny-railroads-sector.asp>, accessed September 14, 2017.

¹⁵ Bonk, M., Ed., "Railroad Track Worker," *Transportation*, 9th Edition, Macmillan Reference Detroit, 2007, p. 65.

had fallen to approximately 225,000.¹⁶ BMWED currently has approximately 35,000 members. Automation, productivity, the rise of trucking and airline transportation, and the split off of Canadian workers has reduced both potential and enrolled membership. Also, many maintenance-of-way jobs have been contracted out. In 2004 the BMWED merged with the International Brotherhood of Teamsters to become a part of the Teamster Rail Conference.¹⁷

BMWED leaders continue to work for job security, better working conditions, fair wages and benefits, improved safety conditions, training, and appropriate work force levels. The benevolent society that started with a few trackmen in Alabama works to meet the challenges and problems of an ever-changing industry and to protect its members' rights. Among the benefits that the union has won for its members are:¹⁸

- Right of Representation
- Rules Agreements
- Overtime Pay
- Unemployment Benefits
- Paid Vacations
- Union Shop
- Off-Track Vehicle Accident Insurance Coverage
- Accidental Death, Dismemberment and Loss of Sight Benefits.
- Job Security
- Health Insurance
- Checkoff of Dues
- Dental Insurance
- Bereavement Leave
- Protection against Discrimination
- Eight-hour day
- Retirement Benefits
- Sickness benefits
- Forty-hour Week
- Holiday Pay
- Life Insurance
- Improved Wage Rates
- Travel Time and Away-From-Home Expenses
- Jury Duty Pay
- Supplemental Sickness Benefits
- Early Retiree Major Medical Benefits
- Personal Leave.

In 2017 the straight time hourly wage for BMWED-represented track maintenance equipment operators was \$27.93. Thus, the annual average wage was \$58,094, and with benefits,¹⁹ the total annual compensation was \$84,204.²⁰ (See Appendix IV for discussion of wages and benefits.)

¹⁶ Hertel, D.W., *History of the Brotherhood of Maintenance-of-Way Employees: Its Birth and Growth, 1887-1955*, Ransdell Inc. Publishers, Washington, DC, 1955.

¹⁷ Brotherhood of Maintenance of Way Employees, "About Us," <http://www.bmwe.org/aboutus.shtml>, accessed November 1, 2015.

¹⁸ Brotherhood of Maintenance of Way Employees, IBT, "BMWED-IBT: History and Accomplishments," <https://www.bmwe.org/secondary.aspx?id=22>, accessed October 27, 2016.

¹⁹ Total employer paid cash, non-cash compensation and payroll taxes, less employee cost-sharing and employee payroll taxes.

²⁰ Brotherhood of Maintenance of Way Employees Division, IBT, "Memo to All BMWED Division and System Officers from President Freddie N. Simpson," on compensation package, March 10, 2017.

D. CONTEXT OF SOCIAL AND ECONOMIC IMPACT WITHIN OVERALL BMWED HEALTH AND SAFETY STUDY

While nearly all MOW on-the-job illnesses and many accidents are preventable, this report found, through survey, interviews, and focus groups that the operating and safety culture in the rail industry does not seem to put priority on prevention. Beyond that, cultural “fear of reporting” discourages injured and ill employees from reporting their injuries and illnesses, thus postponing treatment that could resolve or improve an individual’s health outcome. Fear of being taken out-of-service or permanent dismissal was a major theme throughout the surveys, interviews, and focus groups done as part of this research. Out of fear of losing their livelihood, many maintenance-of-way workers say that they suffer silently, use vacation time to seek health interventions, and often go to work sick or injured, exacerbating some conditions.

Many of the direct medical costs associated with BMWED-represented maintenance-of-way employee injuries and illnesses are covered by negotiated health insurance – and this saves workers many out-of-pocket expenses, but these costs must still be covered and, when not covered out-of-pocket by the employee, they are borne by railroad and insurance companies. While maintenance-of-way workers generally have no paid sick days, partial pay for time out of work may be covered by other negotiated supplemental sickness benefits, and this cost is born primarily by the employer (both for supplemental sickness benefits and for replacement costs of the person out of work). The affected worker has less income and his/her family must adjust to financial changes as well as the ability of their loved one to maintain family relationships and responsibilities. As the literature presented here finds, an individual in pain may be unable to do basic chores and home maintenance and may experience mood and even personality changes. Children and partners may have to fill in the gaps and live with the changes. Many of the social and economic impacts of injury and illness are borne by the individual and his/her family, but are also a burden on employers, insurers, the surrounding community, and taxpayers.

I. HEALTH AND SAFETY RISKS TO MAINTENANCE-OF-WAY WORKERS

To assess the health and safety risks to maintenance-of-way rail workers, information was collected both from BMWED members themselves (a survey, interviews, and 2 focus groups) and through a review of other research on the subject.

An extensive survey was made available to all active and retired BMWED members of record to collect information about their health, injuries and illnesses as a result of their work with the railroads. They also reported on their health experiences and expenses. The survey could be filled out online, on hard copy or by talking to a researcher who recorded their answers to the questions.

In addition, in-depth telephone interviews with 155 active and retired BMWED members yielded a myriad of stories about work experiences, injuries and illnesses and those of their union brothers and sisters.

In 2017 two focus groups with active BMWED members were held, one with 15 individuals from the same geographical region of the US and one with 24 members from at least 22 states and six

different railroads.²¹ The purpose was to engage in a discussion to probe the impact of workplace injuries and illnesses on an individual's life, the life of family members, and the impact on the community, as well as to hear more generally about their health and safety concerns.

The risks and challenges of life as maintenance-of-way workers are clear from testimonials culled from survey, interviews, and focus groups. The economic and social impacts are also clear. The literature supports these comments from the rank-and-file.

A. OVERVIEW OF INFORMATION GATHERED FROM SURVEYS, INTERVIEWS, AND FOCUS GROUPS WITH BMWED MEMBERS

Most MOW workers “tough it out” when it comes to injury and illness. In-depth interviews and survey comments reveal the stoical irony that many of these workers, despite their description of serious health problems, still regard themselves as basically “undamaged.” It should also be noted that many of these workers have literally watched the death or maiming of their work colleagues on-the-job, often close friends and relatives, and so may not think to provide information about a bad back, joint pain, a smashed finger or toe, hernia surgery, skin cancer, or deteriorating lung condition – considering it incidental in comparison. For example, a recently retired BMWED member working many years for the railroad, reported that after year 1 of employment, he had carpal tunnel in both wrists. By year 2, he suffered from back pain, from year six on he had significant hearing loss (age 30), and then a 3,000-pound panel crushed his thumb requiring surgery. He currently has knee and neck pain as well. But here is how he views his health:

I have been luckier than most so far in my life. I am enjoying my retirement. For the most part pretty healthy. I wear hearing aids because of the railroad (which I had to pay \$4,000.00 for out of my own pocket). I do suffer from carpal tunnel and can no longer ride a motorcycle, but I still am an avid wood worker, love to work on my yard in the country, fishing and camping and stay very active. I have occasional upper back pain and my knees are pretty bad due to years of packing welds when I was a welder (Thermite). For most of my career I felt that we were all put in situations we had to work way too hard due to not enough people to do the jobs. I was also exposed to asbestos for several years when I started, burning asbestos rope and diesel fuel to heat rail. Also, no hearing protection was required till mid-1980's. God willing, I will have many more years of quality retirement with family and friends.

Yet they had a lot to say about their work, health and injury experiences. Here are some of the topics they raised, including some of their comments.

²¹ States included Arizona, California, Colorado, Delaware, Florida, Illinois, Indiana, Iowa, Kansas, Louisiana, Maryland, Massachusetts, Missouri, Nebraska, New Hampshire, New Jersey, New Mexico, New York, Oklahoma, Pennsylvania, Tennessee, Texas.

1. Out-of-Pocket Expenses

More than 850 survey respondents discussed their out-of-pocket expenses due to work-related injuries and illnesses.²² Most were due to joint-related problems – backs, hips, shoulders, knees, ankles, feet, and wrists. But they were also due to cancer treatments, lung care, sight, hearing, and teeth. Some had spent as much as \$10,000 to \$20,000, over the years, on medical devices like hearing aids or for medical devices to support them through struggles with cancer. One interviewee said: “Railroads won’t cover hearing aids but won’t let people work without them.” A survey respondent reported that: “After retiring had to get hearing aid. The railroad said it would not help pay for them, not their problem. Most of [my] hearing loss was due to loud train whistles and other noises.”

For medical devices, it was not uncommon for respondents to have spent hundreds, if not thousands, of dollars for a range of orthotics, boot insoles, and CPAP supplies. Especially because so many BMWED workers live rurally and far from major medical centers, some had spent thousands of dollars over the years just in travel to receive medical care – for problems ranging from skin and kidney cancer to complicated bone fractures and joint replacement surgeries. And in some cases, these travel expenses were matched by hundreds of dollars for overnight stays and/or parking expenses. Many had spent hundreds or even thousands of dollars for over-the-counter pain relief to treat the pain they feel on a daily basis. There were also thousands of dollars for co-pays, in many cases for those who sought chiropractic services for work-related back problems.

Victims suffer from their own lost wages as well as from the lost wages of family members who serve as caretakers. One BMWED member spoke of \$45,000 in lost wages when a spouse had to stay home to take care of him; another of \$25,000 and yet another \$9,000. Many BMWED members reported that they had had expenses but were not sure how much they had spent over the years.

2. Caretakers and Health Aides: Out-of-Pocket Expenses and Lost Wages

Most sick and injured MOW workers indicated that they depend on themselves and their families to provide help, but sometimes that is not possible, and they have to pay for caretakers.

3. Lost Work Due to Work-Related Injuries and Illnesses

Despite the fact that many MOW workers come to work with significant pain and illness, some events leave them with no alternative but to take time off from work. Repeatedly, especially in interviews, workers discussed coming to work sick and injured, suffering through significant pain because they are afraid of being taken out-of-service or dismissed, but sometimes the injuries were just too severe, and they missed work. When close to a thousand survey respondents said why they missed work, only three said colds or flu. Instead, the reasons were things like amputated finger, back surgery, broken ankle, COPD, hernia surgery, kidney cancer, knee or hip replacement, or torn rotator cuff. Of 675 reporting specifically on their time away from work due to injury or

²² As this was the last section of a very long survey, many participants simply failed to respond to these questions.

illness, 60 percent were out of work for more than a month and 13 percent were out of work for more than six months. (See Table F in Appendix V.)

4. Pain

Many workers said they suffered from significant joint pain. They said that they don't do as much heavy lifting and bending and twisting as in past decades, but they still do it. When asked if the job was getting any easier, 24 of 24 in the second focus group, said "NO!!!"

5. Working Shorthanded

When a worker is out sick, the gang often works short, with no replacement help available. All fifteen workers, in the first focus group, said they are expected to cover or help pick up the slack when a coworker was off injured or sick.

6. Perception of Shortened Life

According to one interviewee, most maintenance-of-way workers don't make it to 60. Some die and some are disabled, but few can continue on the job past the age of 60. Everyone knew people on the job with lung, throat, liver, or brain cancer. Most knew people on their gangs who had cancer before they retired. One participant talked about his work colleague who needed a double lung transplant. Another participant said that if you get sick on the railroad, you die within 12 months.

7. Personal Protective Equipment (PPE)

According to respondents, the work boot allowance and/or boots provided are inadequate. Even when boots are provided, they don't seem to last long, so many maintenance-of-way workers have to spend money out-of-pocket, either to increase the quality of the boots or to replace boots when they wear out. Participants say that one railroad gives no money for boots; another reimburses \$120 per year; another, \$100; and yet another, \$90 per year. Discussion of the boot problem generated several emotional responses in both focus groups. Workers also reported that training on respirators is poor and fit testing is inadequate. And, even if this were done well, they said, the respirator equipment is rarely available. Also, "they qualify you on one thing then supply something totally different."

8. Good Training Would Save Money

If one teaches new employees from the beginning how to use equipment, the equipment will last longer, and employees will have fewer accidents. Often skill training is mandated but does not occur.

9. Injury Reporting

This is a no-win situation in the eyes of many. If you report an injury you can get taken out-of-service or dismissed, and if you don't report an injury and then are forced to report it later, you can lose a week or more in pay or even be dismissed for "late reporting." Respondents felt there were many incentives to not report, besides being taken out-of-service or permanently dismissed.

10. Problems with Scheduling

One thing interrupting family life is rotating shifts, and there are often inadequate hours between shifts. An eight-hour break includes transportation and eating, showering and taking care of family issues, so sleep time is usually no more than five hours. Some of the reported problems with scheduling are related to inadequate work force counts, where only a small pool of employees is available for both scheduled and emergency work.

11. Weed Spraying

Members ask for notification when weed spray trucks will be working, but they say that none of the railroads will do it. According to one interviewee, at least one company sprays glyphosates, a probable carcinogen, and gives no notice, so people have to work in it.

The risks and challenges of life as maintenance-of-way workers are clear from the above testimonials culled from survey, interviews, and focus groups. The economic and social impact is also clear. The literature supports these comments from the rank-and-file.

B. ECONOMIC AND SOCIAL IMPACT OF INJURY AND ILLNESS

The cost of treating and managing diseases can be separated into direct and indirect costs. Direct costs include prescription medications and in- and out-patient treatments such as hospital charges, visits to doctors, chiropractors, physical therapists, etc. Indirect costs usually take into account the impact of illness on the patient's ability to work and costs to the workplace. Unfortunately, many indirect costs are often overlooked because most research is focused on the economic impact of illness or injury on employers and insurers. Very little is known about the indirect impact of specific diseases on other family members' education or employment or psychological well-being. Little is known about how a significant illness or injury affects the patient's and the family's participation in the community and community activities such as sports, Scouts, service organizations, or religious institutions, though common sense says the impacts are significant. This study will put numbers to some, but not nearly all of these factors.

Traditionally, reports on the economic impact of injury and illness focus on direct medical costs only. There are many other direct and indirect costs as well, including the burden to the injured or ill worker, as well as costs to his or her family, employers, insurers, society, and to taxpayers. Increasingly in recent years, there has been an effort to also include the economic impact of reduced productivity from lost work days as an indirect cost. Absenteeism is one important factor affecting productivity. While the cost of absences is more often being measured, rarely measured

is the economic burden of “presenteeism,”²³ or the lower productivity of a sick or injured worker who comes to work but cannot perform tasks fully or efficiently. And, even more rarely calculated is the presenteeism of caregivers – workers who often are exhausted and may need to use work time for making arrangements for their injured or sick loved ones. Studies of absenteeism and presenteeism provide evidence that if one wants to increase productivity, part of the solution is “an integrated approach to mitigate job-related injuries, promote employee health, and improve the fit between a worker’s duties and abilities.”²⁴

A key difficulty in estimating the social and economic cost of occupational illness and injury among railroad track maintenance workers is the significant amount of underreporting. (See Appendix VI for a more detailed discussion of this issue.)

This report calculates direct and indirect costs for just five health problems faced by maintenance-of-way workers – chronic obstructive pulmonary disorder (COPD), chronic kidney disease, cancer, back problems, and carpal tunnel syndrome. There are many other serious and enduring problems faced by these workers for which costs are not calculated. Hernia or rotator cuff repair often means weeks off the job and high medical costs; likewise, for knee and hip replacement as well as bone fractures and serious lacerations. As high as the cost calculations are in this study, they are conservative for what they measure, and what they measure is just a fraction of total social and economic burden. (See Appendix I for discussion of the ways in which assumptions and methodology for cost estimates are conservative.) Because the distribution of costs varies based on geography, insurance, employee benefit plans, and family circumstances, total costs are not specifically allocated to workers and their families or to employers, insurers, or taxpayers. Each bears significant burden.

1. Direct Medical Costs

Direct medical expenditures are the most frequently measured costs when estimating the burden of a workplace accident or illness. They include the cost of doctor visits, hospital stays, therapy visits, medical equipment and devices, and prescription medication. But there are many other medical costs as well that may, or may not, be counted. These include chiropractic and acupuncture, out-of-pocket spending on over-the-counter drugs or medical devices, home health care visits and visiting nurses, and nursing homes and rehabilitation centers.

Health care expenditures in the United States are in the hundreds of billions of dollars every year. The burden of those costs is distributed across a wide arrange of payers. (See Table 1.)

²³ Wang, P. et al., “Chronic Medical Conditions and Work Performance in the Health and Work Performance Questionnaire Calibration Surveys,” *JOEM*, Vol 45, No 12, DOI: 10.1097/01.jom.0000100200.90573.df., December 2003, p. 1303.

²⁴ Jinnett, K. et al., “Chronic Conditions, Workplace Safety, and Job Demands Contribute to Absenteeism and Job Performance,” *Health Affairs*, 36, No 2, doi: 10.1377/hlthaff.2016.1151, pp. 237-244.

Table 1: Distribution of Total Incremental Costs of Medical Expenditures by Sources of Payment	
Source of Payment	Percent of Total Cost
Out of pocket	17%
Medicare	25%
Medicaid	8%
Private insurance	43%
Department of Veterans Affairs/TRICARE/other Federal programs	3%
State/other public programs	1%
Workers' compensation	1%
Other sources	2%
Total	100%

Source: Based on Gaskin and Richard (See bibliography - Based on authors' calculations using the 2008 Medical Expenditure Panel Survey.)

Some sources place the share of federal expenditures for medical costs at over 60 percent, and for some diseases even 70 percent or more, thus placing a major burden for occupational injury and illness on the U.S. taxpayer.

2. Indirect Costs

Indirect costs for medical problems include those that are not included in medical treatment or hospital/health institution prices. They include such familial, societal and economic effects of disease as lost wages, increased use of social safety-net programs, and social and psychological impact on families and communities, transportation, over-the-counter medications, etc. Most available data are for economic direct and indirect costs rather than the cost related to family relationships and community functioning.

a. Lost Productivity. Much lost productivity comes from workers with chronic health conditions²⁵ -- many of those conditions caused by the work itself. Jinnett et al. found that adding absence from work and the lower productivity of coming to work with injuries or illnesses (presenteeism) could easily cost a typical U.S. employer more than \$1,000 per employee per year for the total work force. (For such high injury and illness jobs as maintenance-of-way, the dollar value is likely to be much higher.) The \$1,000 estimate did not include production delays, use of replacement staff or overtime, and extra work required of other employees which could raise the estimate,²⁶ and is only a rough estimate of the burden of lost productivity.

b. Absenteeism. Absenteeism is a major cost associated with illness and injury. There is the cost of absence for the victim, for family caregivers who stay home to help the victim, and the "recovered" victims, who, while mostly better, still may have recurring health problems that keep them away from work for medical treatments or for rest.

²⁵ Ibid.

²⁶ Ibid.

For cancer patients alone, one study showed that lost wages (just a partial measure of absenteeism), were, on average, over \$800 a month.²⁷ And then there are the costs associated with absenteeism among cancer survivors, not included in calculations of those considered active patients. In 2016 dollars, based on an NIH estimate,²⁸ lost wages amount to \$8.5 billion in 2016 dollars nationwide. Estimates for losses to business are more than \$28.6 billion in 2016 dollars, due to absenteeism of caregivers alone.²⁹ Back pain, a major problem for many MOW workers is a major cause for absenteeism, and according to the World Health Organization about 37 percent of back pain is from occupational risk factors.³⁰

c. Presenteeism. According to a study by Wang, et al., more work performance can actually be lost from presenteeism than from absenteeism. The Wang study goes on to report that conditions which may limit an individual from full productivity, and that are major issues for maintenance-of-way workers, include arthritis, back pain, asthma, and COPD. Having programs to prevent these diseases and treat them early could well yield a positive return on investment for employers by reducing presenteeism. Whereas absenteeism for arthritis averaged 8.5 lost days a year, presenteeism led to estimated lost productivity, on average, of 15.6 days per year. For those with cancer, where the actual lost work days is 2.4 on average, the presenteeism effect was found to be 12.3 lost days. For COPD, with an average absenteeism of 19.4 days per year, the annual presenteeism rate was 27.5 days lost.³¹

d. Impacts on Families. The economic, social, and health impacts of having a severely injured worker in the family can be profound. “For many injured workers and their families, a workplace injury creates a trap which leaves them less able to save for the future or to make the investments in skills and education that provide the opportunity for advancement. These injuries and illnesses contribute to the pressing issue of income inequality: they force working families out of the middle class and into poverty.”³²

Approximately 10 percent of children in the U.S. grow up with a parent who has a chronic medical condition. Negative consequences for the children can include internalizing problems, stress, and

²⁷ Stommel et al. in Fortner, B. et al., “Description and Predictors of Direct and Indirect Costs of Pain Reported by Cancer Patients,” *Journal of Pain and Symptom Management*, Vol 25, No 1, January 2003, p. 11.

²⁸ Tangka, F. et al., “State-Level Estimates of Cancer-Related Absenteeism Costs,” *JOEM*, Vol 55, No 9, September 2013, p. 1017.

²⁹ AARP, “Valuing the Invaluable: The Economic Value of Family Caregiving, 2015 Update,” AARP Public Policy Institute, 2015, <http://www.aarp.org/content/dam/aarp/ppi/2015/valuing-the-invaluable-2015-update-new.pdf>, accessed January 24, 2017, p. 7.

³⁰ World Health Organization, “The world health report, Chapter 4, Selected Occupational Risks,” 2002 <http://www.who.int/whr/2002/chapter4/en/index8.html>, accessed 2016.

³¹ Wang, P. et al., p. 1303.

³² U.S. Department of Labor, Occupational Safety and Health Administration, “Adding Inequality to Injury: The Costs of Failing to Protect Workers on the Job,” June 2015, <https://www.dol.gov/osha/report/20150304-inequality.pdf>, accessed October 29, 2016, p. 2.

a lower GPA.³³ The percentage of children in families with chronic illness and/or disability is likely higher for children of maintenance-of-way workers. Children may live without a real childhood due to caretaking responsibilities.³⁴ Compromised parenting because of stress and illness leaves many children with developmental problems.³⁵ The lives of these children often alternate between responsibility and loneliness.³⁶ Older children are likely to help care for sick and/or disabled parents. Some children find greater appreciation of life and emotional strength, but others suffer from anxiety and depression.³⁷ Generally, the caregiving experience negatively affects a child's physical and mental health and schooling.³⁸ One study of children of parents with chronic renal failure found lower school performance, increased aggression at home and with peers, and difficulty socializing.³⁹ Problems in cognitive and physical functioning are reported in the literature.⁴⁰ In some families, the stress of disability, or its associated depression, may lead to substance abuse, physical abuse, and sexual abuse, and there are many studies documenting the fact that children living with domestic violence are themselves at an increased risk of emotional, physical and sexual abuse, of developing their own emotional and behavioral problems and of increased exposure to adversities in their lives.⁴¹ One study found that half of the children from families with cancer or a mental disorder had psychosocial problems.⁴² Other studies have found that workplace injuries can "diminish self-esteem and self-confidence, increase stress between

-
- ³³ Sieh, D., Visser-Meily, J., Meijer, A., "Differential Outcomes of Adolescents with Chronically Ill and Health Parents," *J Child Fam Stud*, DOI 10.1007/s10826-012-9570-8, 2013.
- ³⁴ Bjorgvinsdottir, K., Hallodorsdottir, S., "Silent, invisible and unacknowledged: experiences of young caregivers of single parents diagnosed with multiple sclerosis," *Scand J Caring Sci*, 2013, p. 38.
- ³⁵ Foster, G., "Children who live in communities affected by AIDS," *The Lancet*, Vol 367, February 25, 2006, p. 700.
- ³⁶ Ahlstrom, B., Skarsater, I., Danielson, E., "Children's View of a Major Depression Affecting a Parent in the Family," *Issues in Mental Health Nursing*, DOI: 10.3109/1612840,2911,579689, 2011, p. 560.
- ³⁷ Stoeckel, M., Weissbrod, C., Ahrens, A., "The Adolescent Response to Parental Illness: The Influence of Dispositional Gratitude," *J Child Fam Stud*, DOI 10.1007/s10826-014-9955-7, 2015, p. 1505.
- ³⁸ Zhang, L. et al., "'I felt I have grown up as an adult'," *Child: care, health and development*, DOI:10.1111/j.1365-2214.2009.00973.x, February 2009, p. 542.
- ³⁹ Coldstream, F., "A literature review of the potential effects of having a parent with chronic renal failure," *Journal of Clinical Nursing*, DOI: 10.1111/j.1365-2702.2007.02154x, 2006, p. 102.
- ⁴⁰ Visser, A., et al., "The impact of parental cancer on children and the family: a review of the literature," *Cancer Treatment Reviews*, DOI: 10.1016/j.ctrv.2004.06.001, 2004.
- ⁴¹ Holt, S., Buckley, H., Whelan, S., "The impact of exposure to domestic violence on children and young people: A review of the literature," *Child Abuse and Neglect*, 32, DOI: 10.1016/j.chiabu.2008.02.004, 2008.
- ⁴² Krattenmacher, T., et al., "A comparison of the emotional and behavioral problems of children of patients with cancer or a mental disorder and their association with parental quality of life," *Journal of Psychosomatic Research*, Vol 76, Issue 3, March 2014, [http://www.jpsychores.com/article/S0022-3999\(13\)00436-4/fulltext](http://www.jpsychores.com/article/S0022-3999(13)00436-4/fulltext), accessed February 2016, p. 213.

spouses, children and other family members, and strain relations with friends, colleagues and supervisors.”⁴³

Families with seriously injured or ill individuals can become unstable – finances become precarious, making housing and food security and health interventions unpredictable. If families become unstable, it affects entire communities.⁴⁴ Children from these families may need more attention and services in school. In some instances, there may be substance abuse in the family and more need for police and social services. Sick and injured individuals and family members are likely to be less able to volunteer to coach sports, lead Scout troops, be active in their places of worship, or serve on local boards and committees. Local resources may be needed to help these individuals and families – from EMT to meals-on wheels, from housing assistance to visiting nurses and food stamps.

The health of the whole family suffers when a family member has a serious injury or illness. A 2015 study in the *American Journal of Industrial Medicine* found that “family members of severely injured workers had a 15% increase in the total number of MSD [musculoskeletal disorder] outpatient claims and a 34% increase in the mean cost of MSD claims compared to family members of non-severely injured workers within 3 months after injury.” There were other problems as well. For example, about half of Maryland workers’ compensation claimants who had upper extremity musculoskeletal disorders said that their conditions resulted in family problems, including marital separation by 11 percent of them.⁴⁵

Sixteen percent of these workers with MSD needed care from family members. And 38 percent of the family members of those with MSD also had to take on extra household chores that used to be done by their injured family member. Loss of income from the injured worker often led to reduced family income which limited the ability to hire caretakers, so family members, in order to care for the injured worker, reduced their work hours and lost even more household income.⁴⁶

⁴³ Keogh, J.P., Nuwayhid, I., Gordon, J.L., Gucer, P.W., “The impact of occupational injury on injured worker and family: Outcomes of upper extremity cumulative trauma disorders in Maryland Adding Inequality to Injury: The Costs of Failing to Protect Workers on the Job workers,” *American Journal of Industrial Medicine*, 2000; 38:498–506; Pransky, G., Benjamin, K., Hill-Fotouhi, C., et al., “Outcomes in work-related upper extremity and low back injuries: Results of a retrospective study,” *American Journal of Industrial Medicine*, 2000; 37: 400–409; Strunin, L., Boden, L.I., “Family consequences of chronic back pain,” *Social Science and Medicine*, 2004; 58:1385-1393; Mocan, N., Tekin, E., “Obesity, self-esteem and wages,” 2009 National Bureau of Economic Research NBER Working Paper No. 15101. Benabou, R., Tirole, J., “Self-confidence and personal motivation,” *The Quarterly Journal of Economics*, 2002; 117:871-915; and Bowles, S., Gintis, H., Osborne, M., “The determinants of earnings: A behavioral approach,” *Journal of Economic Literature*, 2001; 1137-1176 cited in U.S. Department of Labor, Occupational Safety and Health Administration, “Adding Inequality to Injury: The Costs of Failing to Protect Workers on the Job,” June 2015, <https://www.dol.gov/osha/report/20150304-inequality.pdf>, accessed October 29, 2016, p. 5.

⁴⁴ Snell, T., “Fragile families take toll on communities – Organizations looking for ways to work together to lend a hand,” *Tahlequah Daily Press*, May 20, 2014.

⁴⁵ Ibid.

⁴⁶ Asfaw, A. Pana-Cryan, R., Bushnell, T. and Sauter, S., “Musculoskeletal Disorders and Associated Healthcare Costs Among Family Members of Injured Workers,” *American Journal of Industrial Medicine*, 58: 1205–1216, doi:10.1002/ajim.22500, 2015, pp. 1205, 1206.

Some families face moving to lower cost housing, taking out a home equity loan, foreclosure or eviction, having a car repossessed, food compromises, legal matters due to unpaid medical bills, using credit cards to pay medical debt, not to speak of “wounded pride.” Some have to move in with family members, disrupt their doctor-patient relationship in the middle of treatment, or forego medical treatment for lack of funds.⁴⁷ Though BMWED members benefit from robust union-negotiated health insurance, bankruptcies due to injury and/or illness were still documented by the survey and interviews in this research. One interviewee explained what happened when he was injured on the job and had to go out on disability: “Very hard to survive on half normal wages. My wife had no job but spent lots of time driving me to the doctor. I put my house on the market just before my injury and wound up losing \$100,000 on the sale of the house. I had to declare bankruptcy. Medical bills are still a problem. I sold my 4-wheeler ATV, guns, and tools to make ends meet.” Another said he was considering bankruptcy because of costs associated with his medical bills. He had to borrow money from his parents to meet expenses. He felt like he was in a deep hole with no hope of getting out. Another survey respondent said debt was causing further deterioration of his health: “I have recently gone into debt consolidation and have been putting off getting a professional diagnosis that may interfere with my bill paying. Got to pay what I can till they are paid although it may make my health worse at this time.” As many as one-half of personal bankruptcies in the U.S. are related to medical bills.⁴⁸ In 2012, more than 25 percent of all families faced financial burdens due to medical expenses.⁴⁹ Medical bills can threaten the nonmedical portion of a household budget.⁵⁰ Maintenance-of-way workers are among those who may face these burdens.

When chronic illness stresses a family, the family’s entire community can be weakened. When a family member has a chronic illness, the whole family unit can become “fragile,” putting everyone in the family at risk. Based on a community-wide discussion in Oklahoma, the impact was expressed this way:⁵¹

When families are impacted, the entire community is impacted. Communities are living organisms, just like our bodies. If a child suffers from a broken arm, the whole body and soul is affected. When communities suffer from broken family units, we are all impacted. From a less productive workforce to increased crime, our communities suffer.

⁴⁷ Grande, D., Barg, F., Johnson, S., Cannuscio, C., “Life Disruptions for Midlife and Older Adults with High Out-of-Pocket Health Expenditures,” *Annals of Family Medicine*, 2013.

⁴⁸ Ibid.

⁴⁹ U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, “Financial Burden of Medical Care: A Family Perspective,” NCHS Data Brief, Number 142, January 2014, <http://www.cdc.gov/nchs/data/databriefs/db142.htm>, accessed November 8, 2015. p.1.

⁵⁰ Grande, et al.

⁵¹ Snell.

An Ohio State University researcher⁵² found that occupational injuries and illnesses affect:

- injured workers, coworkers, employers, management, office staff, and safety and health officials
- workers' families, workers' friends, workers' colleagues, and workers' neighbors
- Workers Compensation insurers, other insurers
- health care providers, labor unions, other worker groups
- employer groups, lawyers, judges, regulators, and lawmakers.

The effects included:

- reduced wages, diminished productivity, unemployment, retraining
- stress, depression, anger, stigmatization, isolation, violence, suicide, unhealthy behaviors such as smoking and drugs
- medical care utilization, household tasks passed on, problems with interpersonal communication
- problems with family relationships, sleep and sexual disruption, divorce, reduced community involvement, and discrimination
- physical impairment, disability, pain, negative effects on activities of daily living.

Workers, their families, and taxpayers pay most of the costs of workplace injuries and illnesses.⁵³ In addition, workers earn, on average, \$31,000 less over ten years following an injury in 2014 dollars,⁵⁴ or \$31,874 in 2016 dollars.

Many of the health problems causing these familial and community problems are chronic diseases such as chronic obstructive pulmonary disease (COPD), kidney disease, and some cancers, which are common among maintenance-of-way workers. Musculoskeletal injuries and disorders, common among track workers – like back problems and carpal tunnel syndrome -- are also causes of family and community problems.

⁵² Dembe, A., "The social consequences of occupational injuries and illnesses," *American Journal of Industrial Medicine*, DOI: 10.1002/ajim.113, October 2001, p. 405.

⁵³ U.S. Department of Labor, Occupational Safety and Health Administration, "Adding Inequality to Injury: The Costs of Failing to Protect Workers on the Job," June 2015, <https://www.dol.gov/osha/report/20150304-inequality.pdf>, accessed October 29, 2016, p. 2.

⁵⁴ Seabury SA, Scherer E, O'Leary P, Ozonoff A, Boden L., "Using linked federal and state data to study the adequacy of workers' compensation benefits," *American Journal of Industrial Medicine*. 2014; 57:1165-1173. in *Ibid.*, p. 4.

e. Impacts on Quality of Life

“My body is beat up and wore down after 41 years working on the railroad. My retirement years are miserable.”⁵⁵

Individuals who suffer from work-related illnesses or injuries are often in a life-long struggle to participate in important personal and family obligations and also to sustain the energy to do their job. Because of the fear of being taken out-of-service or permanently dismissed, many injured and ill workers, as affirmed by thousands of surveys and more than 150 interviews with MOW workers, hide their infirmities and do not receive the treatment they need for cure or symptom relief. Many have to give up on hobbies like motor biking, hunting, fishing, and sports because joint pain or breathing problems make pursuing them too difficult. Many need their off hours and even their vacation time for recuperation. Some are in constant pain. Children miss out on a parent’s attention and so does a spouse. Many people with back pain suffer in their sex lives.⁵⁶ The chronic pain and illness, as well as the frequent injuries, makes being a maintenance-of-way worker hard during working hours, but perhaps equally hard during non-working hours.

Below are just a few comments from the survey about how respondents’ quality of life has deteriorated because of their careers:

- ❖ “I have severe wrist and joint pain. I attribute it to using a tamp gun for extended periods of time. Also, the hydraulic impact is used daily to tighten bolts with stripped threads causing extended use and jarring of wrist, elbows, shoulders, and neck. Also, my feet and knees hurt daily because we need to walk miles on the tracks... I have low back pain I [at]tribute to sitting for hours in a pick-up waiting on track time. When I hired out it was customary to try and break a new employee. Either hand spiking or tamping by hand seemed to be the methods of choice. Track supervisor was trying to weed out the weak. Also, I have trouble sleeping at night from years of random call out and shift changes... between working all night and then having to work all day because not enough employees to cover FRA required inspections. Or being told I have to protect my job for fear of contracting it out. I now sleep 3 hours and wake and hopefully fall back asleep before going in to work. It has made me miss more than one family event.”
- ❖ “Worked surfacing foreman for years. Worked in dirty dusty conditions, walked miles daily in ballast. Shoulder and knees worn out they need replaced. Had both hands worked on for carpal tunnel and both feet operated on for Plantar Fac [Fasciitis]. Been retired 3 years. Can't hardly walk.”

⁵⁵ Comment from a BMWED survey.

⁵⁶ Ambler, N., de C Williams, A.C., Hill, P., Gunary, R., Cratchley, G., “Sexual Difficulties of Chronic Pain Patients, abstract,” *The Clinical Journal of Pain*, June 2001, Volume 17, Issue 2., https://journals.lww.com/clinicalpain/Abstract/2001/06000/Sexual_Difficulties_of_Chronic_Pain_Patients.6.aspx, accessed April 15, 2018.

- ❖ “Glad to retire at 60. Wish I could travel and enjoy my retirement better. I have a CPAP for sleep apnea/COPD, use a cane or a walker. I have a stair lift outdoors to get into my house. I [hire out to] have my laundry done because washer/dryer in basement. I am avoiding stairs whenever possible. I have moth-balled my favorite vehicle because it is hard to get into or out of. Bought a used SUV for daily driving because of the large doors and height of the seat.”

II. ECONOMIC AND SOCIAL IMPACTS OF CHRONIC ILLNESS AND INJURIES IN GENERAL

Social and economic impacts caused by an incident often involve third-party payments as well as stress on the victim or his/her family members. The financial pressures on a family can include the need for a caregiver, need for additional income from children or spouse to fill the gap between previous earnings and workers compensation, or psychotherapy for family members to cope with harsh new realities. When children lose their chance at college and higher future earnings, the impact is likely to be hundreds of thousands of dollars over their lifetimes. When an injured worker loses a career path, and for the remaining years of working life is in a job earning less per hour or a job with no retirement benefits, the results can also be hundreds of thousands of dollars lost.

Psychological trauma and physical suffering are just two examples of burdens that defy monetization. Other very real costs may occur as well.

A. COSTS TO THIRD PARTIES HAVE BEEN UNDERESTIMATED

The costs to third parties of accidents and illnesses can be high and have been estimated to be distributed across a wide spectrum of groups. One government study estimated the distribution of third party costs due to accidents, for medical, emergency services, lost market productivity, and lost household productivity among others. (See Table 2 below.)⁵⁷

Table 2: Estimated Source of Payment of Injury Costs by Cost Category, Percent of Total Cost							
	Federal	State	Sub-Total	Insurer	Other	Self	Total
Medical	14.4	9.8	24.2	54.9	6.4	14.6	100.1%
Emergency Services	3.9	75.8	79.6	14.7	1.7	3.9	100.0%
Market Productivity	16.2	3.1	19.3	41.1	1.6	38.1	100.1%
Household Productivity	--	--	0.0	41.1	1.6	57.4	100.1%

Source: U.S. Department of Transportation

⁵⁷ U.S. Department of Transportation, National Highway Traffic Safety Administration, “The Impact of Motor Vehicle Crashes 2000,” 59 Table 22, 2002, available at <http://lhsc.lsu.edu/OutsideLinks/EconomicImpact-1.pdf>, in Shapiro, S., Ruttenberg, R., Leigh, P., “The Social Costs of Dangerous Products: An Empirical Investigation,” *Cornell Journal of Law and Public Policy*, Vol 18, No 3, Summer 2009.

There are also many other potential costs to taxpayers and they can go far beyond medical expenses only. When a maintenance-of-way worker gets hurt or sick, there is the potential tax deduction for health care expenses (in the hundreds of billions of dollars nationally) with a portion of that due to work-related issues, for example, silica-related disease expenditures, or physical therapy for joint issues, or surgeries for joint replacement, or back injury, or carpal tunnel syndrome. There are tens of billions of dollars in earned income tax credit nationally, and a portion of that is due to families qualifying as a result of rail-related disease such as chronic obstructive pulmonary disease, chronic kidney disease, or cancer. And beyond these financial burdens to U.S. taxpayers, the government often absorbs the cost of disability benefits, housing subsidies, unemployment insurance, food stamps, VA care, and a host of other third-party and safety net programs. In addition, lost productivity poses a taxpayer burden because sick individuals, who miss work or are less productive, negatively affect personal and corporate income taxes collected. The total burden to the victims and their families (seen here as potential benefits if a disease is prevented) can run into the millions of dollars per person.⁵⁸

B. POTENTIAL COST IN LIFE YEARS LOST FOR THOSE WHO LIVE RURALLY

Many rail workers live in rural areas, and a 2011 study found that the problem of obtaining adequate health services is especially severe for them. In fact, compared to urban dwellers, life expectancy of those living rurally is one to two years lower due to more remote health care.⁵⁹ This is further exacerbated by the length of time it can take for rural residents, or workers in rural areas, to reach emergency services.

C. COST IN CAREGIVING

Care for seriously ill individuals is increasingly being provided at home, and the impact of illness and disability is likely to affect family members as well as the victim.⁶⁰ Family caregivers are the backbone of long-term care in the U.S.⁶¹ Chronic illness often affects a couple's relationship, parenting, household management, work responsibilities, and social relationships.⁶² Over 75 percent of married people who develop a chronic illness get divorced. And, chronic illness of a

⁵⁸ Ruttenberg, R., "Testimony of Dr. Ruth Ruttenberg, President, Ruth Ruttenberg & Associates, on Behalf of the AFL-CIO Before Administrative Law Hearings on Proposed Silica Rule," Occupational Safety and Health Administration, U.S. Department of Labor, January 2014.

⁵⁹ Tollefson, J., Usher, K., Foster, K., "Relationships in pain: The experience of relationships to people living with chronic pain in rural areas," *International Journal of Nursing Practice*, 2011, doi: 10.1111/j.1440-172X.2011.01963.x, p. 479, <https://www.ncbi.nlm.nih.gov/pubmed/21939479>, accessed February 2016.

⁶⁰ Armistead, L., Klein, K., Forehand, R., "Parental Physical Illness and Child Functioning," *Clinical Psychology Review*, Vol. 15, No. 5, 1995, p. 409.

⁶¹ AARP, "Valuing the Invaluable: The Economic Value of Family Caregiving, 2008 Update," AARP Public Policy Institute, 2008, http://assets.aarp.org/rgcenter/il/i13_caregiving.pdf, accessed January 24, 2017, p. 1.

⁶² Johnston, M., Martin, D., "Long-Term Parental Illness and Children: Perils and Promises," *School Counselor*, Vol. 39, Issue 3, January 1992.

parent can increase the likelihood of psychiatric illness in children, acting-out behavior, social withdrawal, sexual promiscuity, and use of drugs or alcohol.⁶³

Caregivers of those disabled or with long-term health problems, may face out-of-pocket expenses, and employment consequences, as well as the necessity of providing caregiving. The full costs to a family of providing caregiving are often hidden. Employment consequences may include the need to exit (or not be able to enter) the work force, restricted work hours or multiple absences, decreased productivity, and limitations on one's career. In fact, 69 percent of employed caregivers to adults nationwide report making changes to their paid work situation because of caregiving responsibilities.⁶⁴ In the U.S., 47 percent of caregivers of veterans reported quitting paid work entirely or taking early retirement. By working fewer hours and turning down overtime, caregivers suffered a 5 percent to 60 percent reduction in pay.⁶⁵ Absences tend to increase, with full-time employed women who are also caregiving missing on average of 24.7 days of work per year. Fifty-eight percent of caregivers left work early or came in late because of their caregiving responsibilities. Productivity is known to decrease because of mental preoccupation, distractions, making and taking phone calls, low morale, stress, and caregiver fatigue. All of these can reduce not only productivity, but job security as well.⁶⁶

A 2013 estimate by AARP on the cost of caregiving found that the average caregiver provided 18 hours of care a week. Calculated at \$12.51 per hour,⁶⁷ these caregivers did the equivalent of 936 hours of unpaid caregiving a year, for an average value of \$11,709. The total impact from all caregivers was \$470 billion – more than the total of Medicaid spending in 2013, or as much as the sales of the world's largest company, Walmart. Over 60 percent of family caregivers in 2014 were also employed. But, more than one in five (22 percent) left the workforce earlier than planned to care for an ill family member. The estimated amount of income-related losses by family caregivers aged 50 and older who leave the workforce to care for a family member, according to AARP, was on average \$303,880 in lost income and benefits over the caregiver's lifetime. In 2016 dollars this amount would be \$313,076. And these numbers are conservative because they are largely based on care of a parent, while disabled BMWED members are likely to be younger and live longer, requiring more years of care. Caregivers themselves are more likely to suffer from depression, anxiety, and more severe physical health problems than non-caregiving peers. In addition, caregivers reported spending an average of \$5,531 out-of-pocket during 2007, or \$6,402 in 2016 dollars, on their caregiving and the needs of their family member. Out-of-pocket expenses can be substantial, including car and home modification to adapt to a person's mobility needs.⁶⁸ Other

⁶³ Ibid.

⁶⁴ Keating, N., Fast, J., Lero, D., Lucas, S., Eales, J., "A taxonomy of the economic costs of family care to adults," *The Journal of the Economics of Aging*, 2014, <http://dxdoi.org/10.1016/j.jeoa.2014.03.002>, accessed February 2016, p. 13.

⁶⁵ Ibid., p. 14.

⁶⁶ Ibid.

⁶⁷ AARP, "Valuing the Invaluable...", pp. 3, 6, 7.

⁶⁸ Ibid., pp. 3, 15.

impacts on a caregiver may include loss of health and pharmacy insurance due to reduced or changed work hours.⁶⁹

Caregiver burnout among intimate partners of patients with a severe illness is also a major issue, with its frequent depression and emotional exhaustion.⁷⁰ Serious illness is a family illness rather than an individual illness, and current caregivers reported lower quality of physical health, compared to widowers who reported being in better health after the death of their spouse.⁷¹

D. COST TO THE RAILROADS

As will be seen in the following pages, five occupational illnesses, measured by excess cases beyond the general U.S. population, cost the railroad industry, workers, their families, insurance companies, and taxpayers (based on the current active population of maintenance-of-way workers in 2016), \$1.7 billion to \$2.3 billion. These are conservative estimates, and yet the numbers are still well into the billions of dollars. While the railroad companies themselves do not pay for all the costs of these diseases and injuries, as the causal party, they should be liable for them.⁷² Class I freight railroads alone are estimated to have \$250 billion a year in operating revenue⁷³ and 20 percent in profit margin and 30 percent in operating margin.⁷⁴ By OSHA estimates, the amount of additional sales required to pay just for the five health issues that are the focus of this paper (COPD, chronic kidney disease, cancer, back problems, and carpal tunnel syndrome), would be \$3.7 billion to \$9.8 billion, based on margins of 20 percent to 30 percent. (See Table 3 below.) Beyond absenteeism, sick pay, disability pay, etc., just presenteeism (poor productivity while on the job, due to pain and disability) is estimated, for these five maladies, alone, to cost the railroads \$150 million to \$286 million over the course of the diseases of current active members. (See Table 11 ahead, following detailed discussion of calculations.)

⁶⁹ Keating, N., Fast, J., Lero, D., Lucas, S., Eales, J., “A taxonomy of the economic costs of family care to adults,” *The Journal of the Economics of Aging*, 2014, <http://dxdoi.org/10.1016/j.jeo.2014.03.002>, accessed February 2016, p. 14.

⁷⁰ Ybema, J., Kuijer, R., Hagedoorn, M., Buunk, B., “Caregiver burnout among intimate partners of patients with a severe illness: An equity perspective,” *Personal Relationships*, 2002, pp. 73, 74.

⁷¹ Trudeau-Hern, S., Daneshpour, M., “Cancer’s Impact on Spousal Caregiver Health,” *Contemp Fam Ther*, DOI 10.1007/s10591-012-9211-9, October 2012.

⁷² Based on the universally accepted economic concept of externalities, economists argue that costs and benefits should be “internalized,” with parties bearing the burden and reaping the benefits of the negative and positive consequences for which they are responsible.

⁷³ Statista.com, “Leading North American railroads in 2016, based on operating revenue,” <https://www.statista.com/statistics/271613/leading-north-american-railroad-companies-based-on-revenue/>, accessed December 7, 2017.

⁷⁴ Maverick.

Table 3: Sales Required to Pay for Direct and Indirect Costs for Five Leading Occupational Illnesses and Musculoskeletal Disorders*	
Health Issue	Sales Required to Make Up for the Total Costs Associated with that Health Issue (Millions of Dollars)
COPD	\$449.6-\$674.4
Chronic Kidney Disease	\$1,118.9-\$1,678.2
Cancer	\$685.1-\$1,027.6
Back	\$1,094.7-\$5,915.5
Carpal Tunnel Syndrome	\$321.4-\$489.1
TOTAL	\$3,669.7 - \$9,777.8

*This research (and calculations that follow) and OSHA's Safety Pays Estimator. Numbers are based on number of BMWED "excess" cases (compared to the number expected for working age men) for each of the five health issues multiplied by the direct+indirect costs that OSHA associates with each if these health problems, over the time for which an individual suffers from that malady. Costs are incurred in various amounts by workers and their families, railroad companies, insurers, taxpayers, and the community at large.

III. FOCUS ON FIVE FREQUENT OCCUPATIONAL DISEASES AND MUSCULOSKELETAL DISORDERS OF MAINTENANCE-OF-WAY WORKERS

Maintenance-of-way workers routinely are exposed to a range of toxic exposures as well as consequences of heavy lifting, bending, twisting, and high levels of vibration. These workers endure high incidences of disease and injury, as borne out by the literature as well as epidemiological studies, survey data, telephone interviews, and focus groups done as part of this overall study. Many of the diseases are chronic and these chronic diseases must be integrated permanently into their lives – a process that is often both complex and challenging. The daily tasks of caring for diseases and injuries, escalating symptoms, and fluctuating emotions can be overwhelming.⁷⁵ And, having a chronic illness leads many to depression.⁷⁶ This study focuses attention on just five severe and chronic health problems faced by many maintenance-of-way workers: 1) chronic obstructive pulmonary disease (COPD), 2) non-cancerous chronic kidney disease (CKD), 3) cancer, 4) lower back problems, and 5) carpal tunnel syndrome (CTS). The relationship of each, at least in part, to maintenance-of-way work exposures and conditions is clear.

Most of these infirmities occur after years of exposure and stress on the body. Knowing when it is appropriate to report a chronic condition can pose a problem to workers – especially for such health problems as chronic obstructive pulmonary disease, chronic kidney disease, carpal tunnel

⁷⁵ Whittemore, R., Dixon, J., "Chronic illness: the process of integration," DOI: 10.1111/j.1365-2702.2007.0244.x, 2008, p. 184.

⁷⁶ Armon, G. et al., "Joint Effect of Chronic Medical Illness and Burnout on Depressive Symptoms Among Employed Adults," *Health Psychology*, Vol 33, No 3, 2014, p. 264.

syndrome, and lower back pain not caused by a specific injury. Some of these issues were discussed by survey participants:

- “Have multiple pains (elbow, knee, back, wrists). Can’t pinpoint specific instance where injury happens, so can’t turn [it] in.”
- “I have serious elbow pain and wrist pain. I’m getting treatment to try to calm it down but no one event can be reported to the railroad because this is a condition that has worsened over time.”
- “A lot of times injuries happen over time. The company wants to know a specific incident that injured you. I know people who put off surgery because they cannot prove an injury happened at work and cannot afford disability.”
- “There was no direct injury that caused my back problems but probably cumulative exposure to bending, lifting, and using different types of railroad-related tools and machines. Lower back pain ended railroad career.”

A. THREE MAJOR CHRONIC DISEASES

Chronic diseases are more prevalent in the U.S. than acute illness and accidents combined.⁷⁷ Yet, because of the long delays between exposure and diagnosis, they are often left in the shadows until diagnosis – even when risk factors are clearly present. The three leading chronic diseases in the United States are cardiovascular, cancer, and chronic respiratory diseases – and maintenance-of-way workers have a significantly increased risk of all of these. A recent standardized mortality ratio (SMR) study of maintenance-of-way workers, by Goldsmith and Barlet, showed rates of 1.62, 1.79, and 1.89 respectively.⁷⁸ A cardiovascular SMR of 1.62 for maintenance-of-way workers means that the likelihood of a maintenance-of-way worker dying of cardiovascular disease is 62 percent greater than for a 18-64 year old male in the U.S. population. Workers could increase their life spans and health significantly with a reduction in these diseases. A study as early as 2005 found that, around the world, each chronic disease prevented would save an average of 14 life years; i.e., without the chronic disease a person, on average, would live 14 years longer.⁷⁹

If the 14-year estimate is applied to the 5,318 excess deaths for COPD (1,308), chronic kidney disease (3,255), and cancer (755) that are calculated later in this report,⁸⁰ for just these three diseases, the BMWED community loses 74,452 life years in excess deaths alone. If calculated to include all MOW workers nationwide, the loss of life years would increase significantly.

⁷⁷ U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, “CDC National Health Report: Leading Causes of Morbidity and Mortality..., 2005-2013,” *MMWR*, October 31, 2014, <https://www.cdc.gov/mmwr/preview/mmwrhtml/su6304a2.htm>, accessed February 2017.

⁷⁸ Goldsmith, D. and Barlet, G., “Follow-up Mortality Study of Certain Craft Railroad Workers, Ages 18-64,” publication pending, 2017.

⁷⁹ Strong, K., Mathers, C., Leeder, S., Beaglehole, R., “Preventing chronic diseases: how many lives can we save?” *Chronic Diseases* 1., *The Lancet*, DOI: 10.1016/S0140-6736(05)67341-2, October 2005, p. 1.

⁸⁰ The SMR was based on data from 1979-2014. Assumed in this report is that SMRs are the same for MOW workers currently active and on-the-job.

Because of the increase in chronic disease, more and more people are living with chronic pain. With chronic pain often come medical, emotional, and economic burdens which can negatively affect every aspect of an individual's quality of life, including family relationships, home responsibilities, and friendships.⁸¹ An individual may have to give up job, hobbies, and/or household responsibilities. According to the Institute of Medicine and the American Pain Society, the total national cost of pain ranged from \$560 billion to \$635 billion a year in 2014 dollars, or \$576 billion to \$653 billion in 2016 dollars.⁸² These costs include direct treatment and lost productivity, but they are considered conservative calculations.⁸³ These pain estimates are greater than the combined annual costs of heart disease, cancer, and diabetes in the United States.⁸⁴

Many maintenance-of-way employees live with chronic pain. Whether in their back, neck, shoulders, hips, knees, hands, elbows, or feet, MOW work -- with its lifting and bending and high-vibration tools -- often leaves workers in pain. One surveyed worker explained that he has multiple aches and pains due to vibrations from the tools used on the job which all weigh 50-lb.+, such as hydraulic tampers, spikers and impact wrenches. Hand tools such as spike pullers (claw bars), sledgehammers, spike mauls, plus lots of shoveling add to the cumulative effect. Another survey respondent said he was "living in pain constantly." And another said, "Chronic pain in shoulder, hip, wrist, and knees." Living with chronic pain, "impacts on every aspect of their life."⁸⁵

Pain affects not only the victim, but also family members, resulting in physical, social, and emotional changes for them all. Family members report "feeling powerless, alienated, emotionally distressed, and isolated" as a result of their family member's pain.⁸⁶ They also report losing friends because of having a family member with a chronic illness. And those with the chronic pain often feel guilty because of the burden they feel they are putting on other family members. Pain can become the most influential factor that binds the family together, more or less becoming, unfortunately, a defining characteristic of a family, and up to 83 percent of spouses report significant depressive symptomatology for themselves as well as a loss of sexual expression and intimacy.⁸⁷

⁸¹ Muneer, S., "Socioeconomic Burden of Chronic Pain," *American Health and Drug Benefits*, October 2015, <http://www.ahdbonline.com/articles/2003-socioeconomic-burden-of-chronic-pain>, accessed February 9, 2016.

⁸² U.S. Department of Labor, Bureau of Labor Statistics, "CPI Inflation Calculator," https://www.bls.gov/data/inflation_calculator.htm, accessed October 19, 2017.

⁸³ Muneer.

⁸⁴ Gaskin, D. J. and Richard, P., "The economic costs of pain in the United States." Appendix C in Institute of Medicine (US) Committee on Advancing Pain Research, Care and Education. *Relieving Pain in America: A Blueprint for Transforming Prevention, Care, Education, and Research*, Washington DC, National Academies Press, p. 715, 2011, <https://www.ncbi.nlm.nih.gov/books/NBK92521/>, accessed November 15, 2016.

⁸⁵ West, C., Usher, K., Foster, K., Steward, L., "Chronic pain and the family: the experience of the partners of people living with chronic pain," *Journal of Clinical Nursing*, 2012, doi: 10.1111/j.1365-2702.2012.04215.x, p. 3353, abstract at <https://www.ncbi.nlm.nih.gov/pubmed/22834990>, accessed February 2016.

⁸⁶ West, et al.

⁸⁷ Lewandowski, W., Morris, R., Draucker, C., Risco, J., "Chronic Pain and the Family: Theory-Driven Treatment Approaches," *Issues in Mental Health Nursing*, DOI: 10.1080/01612840701522200, 2007.

Those in chronic pain and their family members experience financial loss, family loss, loss of friendships, and loss of social activities. Family members may also incur additional injuries themselves. A study by the National Institute for Occupational Safety and Health, with Northern Kentucky University,⁸⁸ found family members of injured workers had 34 percent more fractures, sprains, joint dislocations, and musculoskeletal disorders in the three months following the victim's injury. These excess family injuries were estimated to have cost \$29 million to \$33 million or more a year in 2006 dollars, or \$35 million to \$39 million in 2016 dollars.⁸⁹

Estimates are that annual expenditures on health care were \$4,516 higher per individual with moderate pain, compared to no pain, and an additional \$3,210 per year (or \$7,726 total) if pain was severe rather than moderate. When the pain concerned joints and arthritis (as is often the case with MOW workers), the respective additional costs were \$4,048 and \$5,838⁹⁰ in 2015 dollars, or \$4,132 and \$5,959 in 2016 dollars.

Sometimes the pain for maintenance-of-way workers can be excruciating. According to one survey respondent:

“The sheer pain that my body is in would be enough to floor many men. One of my doctors asked me how I ‘do it’. He said he has seen less damage in patients and they are completely debilitated. Some days I literally scream getting out of bed. Some days I wonder how I am going to get through another day. This job is all I have to take care of my loved ones and they are my world. I do it for them.”

There are many difficulties in calculating costs of chronic illness, pain and otherwise. One study found that between 30 percent and 40 percent or more of those with chronic disease did not fill a prescription because they could not afford the cost.⁹¹ Nonadherence to prescribed medicine can harm health in the long-run and lead to higher medical costs down the road. Approximately one-third of those who fill a prescription take less than prescribed because of cost. The chronically ill also report cutting back on other basic needs because of the costs of care.

⁸⁸ Reported in O’Sullivan, T., “Workplace Injuries Affect Families for Years,” *Lifelines*, February 2016, Vol. 12, No. 9, <https://www.lhsfna.org/index.cfm/lifelines/february-2016/workplace-injuries-affect-families-for-years/>, accessed February 2016.

⁸⁹ Reported in U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, “Occupational Injury: Do Family Members Pay a Price?” NIOSH Research Rounds, Vol 1, Issue 5, November 2015, <https://www.cdc.gov/niosh/research-rounds/roundsv1n5.html>, accessed February 1, 2016, p. 2.

⁹⁰ Muneer, S., “Socioeconomic Burden of Chronic Pain,” *American Health and Drug Benefits*, October 2015, <http://www.ahdbonline.com/articles/2003-socioeconomic-burden-of-chronic-pain>, accessed February 9, 2016.

⁹¹ Piette, J. et al., “Medication cost problems among chronically ill adults in the US: did the financial crisis make a bad situation even worse?” *Patient Preference and Adherence*, Dovepress, DOI: 18.2147:PPA.517363, p.187.

1. Chronic Obstructive Pulmonary Disease (COPD)

Chronic respiratory diseases are problems with the lungs that are either constant or that recur regularly. Most are preventable, though not curable.⁹² Chronic respiratory diseases are frequent causes of disability and death in the U.S. because they make it hard to breathe and get oxygen into the bloodstream. Lower respiratory disease is particularly deadly and chronic obstructive pulmonary disease (COPD) is the deadliest form of lower respiratory disease.⁹³ COPD includes emphysema and chronic bronchitis, both of which restrict airflow to and from the lungs. COPD is not only permanent but is also progressive. There are no treatments to cure it and the disease gradually worsens over time, though the rate of progression can often be slowed if recognized and treated early.⁹⁴ Based on the most recent data available, the Centers for Disease Control and Prevention conclude that lower respiratory diseases are the third most common cause of death in the U.S.⁹⁵ And these numbers are probably underestimated. A Swedish study⁹⁶ in 2006 found that only half of those with severe COPD are properly identified, and many more are misdiagnosed when their disease is less severe. According to a recent Standardized Mortality Ratio (SMR) study, BMWED members were more likely to die from chronic lower respiratory disease than other men aged 18 to 64. The likelihood for a male maintenance-of-way worker dying of COPD is 89 percent greater than the typical U.S. male 18 to 64 years old.⁹⁷

a. Description and Progression of COPD. Because COPD progresses gradually, it is frequently not recognized or diagnosed until long after exposure to the environmental factors that cause it. The most common symptoms of COPD are a chronic cough with regular phlegm, frequent winter bronchitis, wheezing, and difficulty breathing with exertion.⁹⁸

⁹² World Health Organization, “Global Initiative for Chronic Obstructive Lung Disease,” *Pocket Guide to COPD Diagnosis*, 2017, <http://goldcopd.org/wp-content/uploads/2016/12/wms-GOLD-2017-Pocket-Guide.pdf>, accessed March 16, 2017.

⁹³ U.S. Department of Health and Human Services, Office of Women’s Health, “Men’s health: Chronic lower respiratory diseases,” January 2011, <https://www.womenshealth.gov/mens-health/top-health-concerns-for-men/chronic-lower-respiratory-diseases.html>, accessed February 20, 2017.

⁹⁴ U.S. Department of Health and Human Services, National Institutes of Health. National Heart, Lung and Blood Institute, “What is COPD?” 2014, <https://www.nhlbi.nih.gov/health/health-topics/topics/copd>, accessed February 20, 2017.

⁹⁵ Kochanek, K.D., Murphy, S. L., Xu, J., Tejada-Vera, B., “Deaths: Final Data for 2014,” National Vital Statistics Reports Vol 65, No 4, June 30, 2016, https://www.cdc.gov/nchs/data/nvsr/nvsr65/nvsr65_04.pdf, accessed February 20, 2017.

⁹⁶ Lindberg, A., Bjerg-Backlund et al., “Prevalence and underdiagnosis of COPD by disease severity and the attributable fraction of smoking: Report from the Obstructive Lung Disease in Northern Sweden Studies,” *Respiratory Medicine*, Volume 100, Issue 2, February 2006, pp. 264-272, <https://www.sciencedirect.com/science/article/pii/S0954611105001952>, accessed January 25, 2018.

⁹⁷ The SMR was based on data 1979-2014. Assumed in this report is that SMRs are the same for MOW workers currently active and on-the-job. Goldsmith and Barlet.

⁹⁸ Mendes, A., “COPD in the community: working beyond boundaries,” *British Journal of Community Nursing*, Vol 19, No 10, October 2014, p. 514.

A CDC review of the research on COPD reported that adults with COPD are more likely than those without to:⁹⁹

- Have activity limitations such as difficulty walking or climbing stairs
- Be unable to work
- Need special equipment such as portable oxygen tanks
- Not engage in social activities such as eating out, going to places of worship, going to group events, or getting together with friends or neighbors
- Have increased confusion or memory loss
- Have more emergency room visits or overnight hospital stays
- Have other chronic diseases such as arthritis, congestive heart failure, diabetes, coronary heart disease, stroke, or asthma
- Have depression or other mental or emotional conditions
- Report a fair or poor health status.

Although respiratory problems certainly cause some of the disability that people with COPD encounter, Eisner et al. report¹⁰⁰ that non-respiratory complications of COPD account for a separate and significant progression of disability. These non-respiratory conditions associated with COPD include changes in inflammation and fluid retention, reduced cognitive abilities, and mobility problems.

b. Causes of COPD. While the most common cause of COPD is thought to be smoking, recently more recognition is being given to occupational and environmental exposure to air-born contaminants.¹⁰¹ Maintenance-of-way workers have many environmental exposures that can lead to COPD. These include dusts, gases, minerals (including silica and asbestos), polycyclic aromatic hydrocarbons and other chemicals, and welding fumes. Over 30 percent of COPD in nonsmokers is attributable to workplace exposures.¹⁰²

Occupational exposure to silica can lead to COPD and silicosis, a dust-caused disease of the lung.¹⁰³ Silica exposure can also cause lung cancer and kidney disease.¹⁰⁴ Chronic obstructive

⁹⁹ U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, “Chronic Obstructive Respiratory Disease (COPD),” <https://www.cdc.gov/copd/index.html>, accessed October 20, 2016.

¹⁰⁰ Eisner, M.D. et al., “Development of disability in chronic obstructive pulmonary disease: beyond lung function,” *Thorax*, 2010, 66, pp. 108-114. <http://thorax.bmj.com/content/66/2/108.full.pdf>, accessed October 11, 2016.

¹⁰¹ World Health Organization (WHO), “Global Initiative for Chronic Obstructive Lung Disease,” *Pocket Guide to COPD Diagnosis*, 2015, http://www.goldcopd.it/materiale/2015/GOLD_Pocket_2015.pdf, accessed October 10, 2016.

¹⁰² Bang, K.M., et al., “Chronic Obstructive Pulmonary Disease Prevalence Among Nonsmokers by Occupation in the United States,” *JOEM*, Vol 55, No 9, September 2013, p. 1021.

¹⁰³ State of Minnesota, Department of Labor and Industry, Occupational Safety and Health Division, “Health Considerations for Workplace Exposure to Silica,” August 2012.

¹⁰⁴ U.S. Department of Labor, Occupational Safety and Health Administration, “Silica, Crystalline,” n.d., <https://www.osha.gov/dsg/topics/silicacrystalline/index.html>, accessed November 23, 2017.

pulmonary disorder (COPD) and silica exposure also increase the risk of tuberculosis.¹⁰⁵ Virtually all railroads use aggregate stone or slag for track bed ballast. In 2001, granite accounted for approximately 46 percent of the total aggregate stone sold for railroad ballast in the U.S. and granite is 25 to 40 percent silica.¹⁰⁶

The 35,000 active members of the Brotherhood of Maintenance of Way Employees Division, as well as many thousands of retirees, have likely been exposed to silica from track maintenance activities. Track maintenance responsibilities include building, maintaining, inspecting, and repairing the railroad roadbed which is supported by ballast that produces silica dust when stirred up and when manipulated, distributed, and spread along the railroad right-of-way during track maintenance and construction activities.¹⁰⁷ It is estimated that another 35,000 non-BMWED maintenance-of-way workers employed in rail transit, subways, and short line¹⁰⁸ railroads also have similar silica exposures. NIOSH has written about observing maintenance-of-way workers walking in dust clouds alongside moving cars. NIOSH also noted overexposure of workers working on ballast regulators as well as tamper operators and track repair.¹⁰⁹

c. Economic and Social Impacts of COPD. In addition to facing serious long-term disabilities, victims of COPD often die earlier than those without the disease. So, not only is the cost of treatment, medication, and specialized care high for COPD, but there are additional societal costs due to lost time at work, early retirement because of disability, and resulting reduced economic and social resources for family support, housing, and education for the patient and family unit.

The burden of respiratory diseases affects individuals and their families, schools, workplaces, neighborhoods, cities, and states. Because of the cost to the health care system, the burden of respiratory diseases also falls on society; it is paid for with higher health insurance rates, lost productivity, and tax dollars.¹¹⁰

In order to keep their jobs, maintenance-of-way workers, in the survey and interviews for this research, often hide their afflictions – and risk quicker deterioration of their condition and a more

¹⁰⁵ Willis Law Firm, “Silicosis – Silica Dust Exposure to the Railroad Worker,” <http://www.silicosis.com/railroad/>, accessed July 4, 2016.

¹⁰⁶ International Brotherhood of Teamsters, “Comments on Occupational Exposure to Respirable Crystalline Silica,” OSHA Rulemaking, Docket No. OSHA-2010-0034, February 11, 2014.

¹⁰⁷ Ibid.

¹⁰⁸ The nation’s 603 short lines provide service for one in five cars moving each year, operating 47,500 route miles or 29% of freight rail in the US. [American Short Line and Regional Railroad Association, “The Short Line and Regional Railroad Industry,” https://www.aslrra.org/web/About/Industry_Facts/web/About/Industry_Facts.aspx?hkey=bd7c0cd1-4a93-4230-a0c2-c03fab0135e2, retrieved January 6, 2018.]

¹⁰⁹ International Brotherhood of Teamsters, “Comments on Occupational Exposure to Respirable Crystalline Silica.

¹¹⁰ U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion, “Respiratory Diseases,” *Healthy People 2000*, September 16, 2017, <https://www.healthypeople.gov/2020/topics-objectives/topic/respiratory-diseases>, accessed September 17, 2017.

serious outcome. According to one person interviewed: “I have seen others pulled out-of-service because of COPD so I was careful never to miss work.” Another said: “I have COPD now which I contracted 4 years ago -- 2 years before retirement -- but I didn't report it.” Yet another interviewee said: “I never reported that I had asthma or COPD. I always had a fear of letting the company know I had COPD, so I hid it for 4 or 5 years. This was because I had seen others pulled out-of-service due to their inability to breathe. Often, I would be up all night, unable to breathe or sleep.”

Economic Costs of COPD. Determining the cost of a disease is complicated. At the most general level, the costs depend on what stage of the disease one is experiencing, with the costs higher at more severe stages of disease. Costs also fluctuate depending on the treatment within any one stage of the disease. Hospitalization raises costs. Finally, additional costs are incurred if there are comorbidities.

A 2012 study found about half of those with COPD reported that their ability to perform their jobs was limited by their disease.¹¹¹ As with many other diseases, research shows that managing COPD can lead to better quality of life, improved health, lower health care utilization, and lower health care costs¹¹² – all in the interest of workers and their families, their employers, insurers, the community, and taxpayers.

The societal and economic impact of COPD is substantial. Snider et al. studied Americans over 50, who had COPD, to determine how likely they were to collect federal disability benefits such as Social Security Disability Insurance (SSDI) or Supplemental Security Income (SSI) as well as the impact of COPD on employment. They found that COPD goes with an 8.6 percent decrease in the likelihood of employment. They also found that people with COPD are 3.9 percent more likely to collect SSDI and 1.7 percent more likely to collect SSI -- rates of increase much greater than for any other disease. They conclude that, “[o]ur results are consistent with the hypothesis that COPD imposes a substantial burden on American society by inhibiting employment and creating disability.”¹¹³

Leader cites multinational research showing that 37 percent of the people with COPD who were surveyed said that their income had dropped since being diagnosed with COPD.¹¹⁴ Common complications include pneumonia, heart disease, diabetes, asthma, and depression. The CDC website and Tsai et al. report that in 2010 Medicare paid 51 percent of the extra costs of COPD, with Medicaid paying 25 percent and private insurers paying 18 percent – i.e., the federal share of

¹¹¹ Nair, K. et al., “Burden of Illness for an Employed Population with Chronic Obstructive Pulmonary Disease,” *Population Health Management*, Vol 15, DOI: 10.1089/pop.2011.0049, November 5, 2012, p. 268.

¹¹² Ibid., p. 271.

¹¹³ Snider, J.T. et al., “The Disability Burden of COPD,” *COPD: Journal of Chronic Obstructive Pulmonary Disease*, 9(5), 2012, <http://www.tandfonline.com/doi/full/10.3109/15412555.2012.696159>, p. 513.

¹¹⁴ Leader, D., “Can COPD Impact Your Employment? How to live and work with this chronic illness,” Very Well webpage, 2016, <https://www.verywell.com/copd-and-work-914950>, accessed October 11, 2016.

the cost of treating COPD was over 75 percent. Ford et al. found that COPD is costly to the states, too, but how costly varied in 2010 from \$42.5 million in Alaska, to \$2.5 billion in Florida.¹¹⁵

In addition to direct costs of diseases, there are also substantial indirect costs, including the economic effects of disease like lost wages, increased use of safety-net programs, as well as social and psychological effects on families and communities. While the indirect costs are far less studied and often difficult to determine with precision, they are important to include in any calculations. Patel et al. reviewed studies which looked at indirect costs in terms of missed days of work, limited ability or inability to work, days with restricted activity, use of sick or disability days, and of confinement to bed. They found that indirect costs contribute a substantial amount to the total costs, but also found great variability in the costs depending on the population that had been studied (age, sex, severity of disease, etc.).¹¹⁶

Of 53 studies identified, eleven met eligibility criteria, with data years spanning 1987–2009. Estimates of workforce participation range from 56% to 69% among individuals with COPD and from 65% to 77% among individuals without COPD. Approximately 13%–18% of those with COPD are limited in the amount or type of work they can do and one-third or more experience general activity limitation. Estimates of restricted activity days range from 27–63 days per year. Estimates of mean annual sick leave and/or disability days among employed individuals with COPD range from 1.3–19.4 days. Estimates of bed confinement range from 13–32 days per year. Estimated mean annual indirect costs were \$893–\$2,234/person (US dollars) with COPD (\$1,521–\$3,348 in 2010 and varied with the population studied, specific cost outcomes, and economic inputs. In studies that assessed total (direct and indirect) costs, indirect costs accounted for 27%–61% of total costs, depending on the population studied.

Another important consideration is the frequency with which COPD is a co-morbid condition with other serious diseases which significantly add to cost. Costs, on average tend to double with comorbidity.¹¹⁷

Social Costs of COPD. Liu et al. found in their review of the literature that people with COPD were less able to keep up with what they needed to do to live independently as their COPD got worse. This, in turn, often led to disability, isolation from others, and psychological problems like depression. Furthermore, the worse the COPD, the more likely it was that the patient would

¹¹⁵ Ford, E.S. et al., “Total and State-Specific Medical and Absenteeism Costs of COPD Among Adults Aged ≥18 Years in the United States for 2010 and Projections Through 2020,” *Chest* 147(1), 2015, pp. 31 – 45, available at http://journal.publications.chestnet.org/data/Journals/CHEST/931880/chest_147_1_31.pdf, accessed 2016.

¹¹⁶ Patel, J.G., Nagar, S.P., Dalal, A.A., “Indirect costs in chronic obstructive pulmonary disease: A review of the economic burden on employers and individuals in the United States,” *International Journal of COPD*, 9, 2014.

¹¹⁷ Huber, M.B. et al, “Excess Costs of Comorbidities in Chronic Obstructive Pulmonary Disease: A Systematic Review,” *PLOS ONE*, 10(4), e0123292, DOI: 10.1371/journal.pone.0123292, <http://journals.plos.org/plosone/artoc?eod=10.1371/journal.pone.0123292>, accessed September 4, 2015.

have other chronic diseases as well. And these problems are complicated by the role of aging in disease progression. All of this increases the likelihood of death.¹¹⁸

Like many other studies, the Patel et al. review of the literature was based on wage losses and costs as its primary measure of indirect cost. Therefore, it did not research costs to families and communities. For example, there are limited data on how much income was reduced because family members could not go to college, or if the family lost its house or car because they could not make loan payments, or the psychological impact of chronic illness on immediate and extended family members and family relationships. Leader reported that 80 percent of people with COPD said that they could not maintain the lifestyle they had had before being diagnosed.¹¹⁹

The World Health Organization also reports that assessments of indirect costs of COPD usually fail to capture costs to families such as the economic value of the care provided for the patient and the frequency with which both the patient and the caregiver must quit or cut back on work in order to provide care for the family member with COPD.¹²⁰

Simpson et al. define caregiver burden as having at least two main components: *objective burden*, ‘the time spent on care giving, the care-giving tasks that are performed, and possible financial problems,’ and *subjective burden*, ‘the physical, psychological, social, and emotional impact caregivers experience in giving care’ and how caregivers feel about providing care. In their review of the literature, Simpson et al. found reports of the following among informal caretakers of COPD patients:¹²¹

- Caretaking is often demanding, lonely and depressing, in part because there is little recognition or reward economically, socially or professionally.
- The older the patient, the more difficult it is for the caregiver.
- Caring for a partner with COPD reduces intimacy and reduces the rewards and reinforcement that providing care might otherwise bring to the relationship.
- When the patient has emotional difficulties dealing with their COPD, negative effects on family and friendship relationships follow.
- On the other hand, a number of caretakers felt that giving their loved ones the best possible care at the end of their lives was worth the difficulties and felt “enhanced self-esteem and/or self-efficacy, personal growth, and insight.”

When they analyzed what they learned from interviews with 14 informal caretakers of COPD patients, Simpson et al. added details to what others have reported. They found that as the disease progressed and the patient lost mobility and autonomy, caregivers also reported losing freedom,

¹¹⁸ Liu, Y. et al., “The association of chronic obstructive pulmonary disease, disability, engagement in social activities, and mortality among US adults aged 70 years or older, 1994–2006,” 2014:9 75–83.

¹¹⁹ Leader, D., “Can COPD Impact Your Employment? How to live and work with this chronic illness,” Very Well webpage, 2016, <https://www.verywell.com/copd-and-work-914950>, accessed October 11, 2016.

¹²⁰ World Health Organization (WHO), “Global Initiative for Chronic Obstructive Lung Disease...”

¹²¹ Simpson, A.C. et al., “A day at a time: caregiving on the edge in advanced COPD,” *International Journal of COPD*, 2010:5 141–151, p. 142.

security, and stability in their relationship. Loss of common couple and family activities also led to questions about the caregiver's identity as part of a couple and about a family with a critical member absent for most activities. "To sum up, the burden of disease induced relational impact for caregivers appeared to reside in the questioning/shift/loss of relational and personal identity, self-concept, and caregiving motivation."¹²²

Giacomini et al. reviewed the literature on what it is like to live with COPD, revealing stresses for both the patient and the family.¹²³ They found that patients often do not realize how deadly COPD is, sometimes because physicians do not understand this either. Living with COPD is not a predictable experience, making it hard for patients and their families to adjust and plan even a day ahead. As COPD progresses, the patient becomes more dependent on others, creating many problems from resisting dependency to not being able to access support because of medical interventions like hospitalization. Being in and out of the hospital is isolating and confusing for the patient and family members who are trying to get to work, school, religious services, and community events. They summarize the experience of those who care for family members with COPD:

- Caregivers' challenges often echo patients' challenges, and include anxiety, uncertainty about the future, helplessness, powerlessness, depression, difficulties maintaining employment, loss of mobility and freedoms, strained relationships, and growing social isolation.
- Caregivers feel pressured by their many roles, struggling to maintain patience when they feel overwhelmed, and often feeling guilty about not doing enough.

d. Costs of COPD to the BMWED Membership and to Individuals. How many maintenance-of-way workers have COPD? The likelihood that a male maintenance-of-way worker will die of COPD is 89 percent greater than the typical U.S. male 18 to 64 years old,¹²⁴ by far overcoming the relative impact of smoking among BMWED members. There were 323 million people in the U.S. in 2016,¹²⁵ 249 million of them over 18 years.¹²⁶ There were an estimated 27 million with COPD, either diagnosed or undiagnosed;¹²⁷ i.e., 10.8 percent of the adult

¹²² Ibid., p. 144.

¹²³ Giacomini, M., DeJean, D., Simeonov, D., Smith, A., "Experiences of living and dying with COPD: a systematic review and synthesis of the qualitative empirical literature," *Ont Health Technol Assess Ser [Internet]*, March 2012, 12(13):1-47, www.hqontario.ca/en/mas/tech/pdfs/2012/rev_COPD_Qualitative_March.pdf, accessed 2016.

¹²⁴ The SMR was based on data 1979-2014. Assumed in this report is that SMRs are the same for MOW workers currently active and on-the-job.

¹²⁵ U.S. Census Bureau, "Population Estimates, July 1, 2016," <https://www.census.gov/quickfacts/fact/table/US/PS-T045216#viewtop>, accessed November 26, 2017.

¹²⁶ U.S. Census Bureau, "Quick Facts, United States, Population Estimates, July 1, 2016," <https://www.census.gov/quickfacts/fact/table/US/PST045216>, accessed November 26, 2017. 22.8% of the U.S. population July 2016 was under 18 years of age, reducing the \$323 million estimate to 249 million in the U.S. 18 years of age or older.

¹²⁷ COPD.com, "Learn COPD Basics," n.d., <https://www.copd.com/about-copd>, accessed November 26, 2017.

population¹²⁸ and 4.2 percent of those were 40 to 70 years old.¹²⁹ In an active BMWED population of 35,000, this would suggest, based on a national average, 1,470 COPD cases. But a Standardized Mortality Ratio (SMR) study¹³⁰ found that the risk of death from COPD for BMWED members, if 1 in the general population, is 1.89 among maintenance-of-way workers. This suggests a COPD population of 2,778 individuals among BMWED members, or 1,308 more deaths (referred to as “excess deaths” by epidemiologists) expected among BMWED members than among their peers.¹³¹ Since 1,470 COPD deaths would be expected in a general population, but based on the SMR, the number of BMWED members would be 2,778, one can assume that the excess (2,778 – 1,470) of 1,308 is related to their job on the railroad.

For occupational disease, OSHA’s Safety Pays Estimator estimates total costs, direct and indirect, for an accident or illness. For occupational diseases, OSHA calculates the direct cost per case of COPD to be \$49,104 and the indirect cost to be \$54,104, for a total cost of \$103,118.¹³² This suggests that the 1,308 excess deaths have a total cost to the BMWED community of approximately \$134.9 million. The Safety Pays Estimator also estimates the amount of sales a company or industry would have to earn to make up for those costs. If one uses a 20 percent to 30 percent profit margin specific for the rail industry,¹³³ the needed sales by companies, just to make up for the cost of excess COPD deaths among maintenance-of-way employees, would be more than \$515,000 at 20 percent and almost \$344,000 at 30 percent. Using these numbers, the sales needed by the railroad industry, just to make up for the cost of COPD among 1,308 excess maintenance-of-way employees who died of COPD because of work would be \$675.0 million to \$450.0 million.

Since the railroads do not cover these expenses for their employees, some of this financial burden will be borne through out-of-pocket family expenditures and some by taxpayers. Many daily living costs increase with long-term illness and treatment – gasoline and parking costs to get to medical appointments, childcare to get to doctor’s appointments, and lower income when missing work

¹²⁸ This includes women and those over 65, who are outside of the SMR study population. Thus, the resulting numbers, are, at best, an estimate.

¹²⁹ Doney, B. et al., “Prevalence of Chronic Obstructive Pulmonary Disease Among US Working Adults Aged 40 to 70 Years,” October 2014, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4555867/>, accessed January 24, 2018.

¹³⁰ Goldsmith and Barlet.

¹³¹ $7,144 - 3,780 = 3,364$.

¹³² These costs are likely low. As discussed, COPD is the cause of the greatest absenteeism of all chronic diseases and workforce participation is 9 percent lower than for those without COPD, accounting for 1.3-19.4 sick days per year. Also, the costs for these diseases acquired from work are spread variably across workers and their families, railroad companies, insurers, taxpayers, and the community at large. Economic theory of externalities argues that those that cause harm should bear the burden of the cost.

¹³³ To the extent that profit margins are higher than the OSHA default of 3 percent, the total amount of sales would be less. But, at the same time, higher profits would indicate an increased ability to (profitably) invest in prevention and treatment. As documented earlier, railroad profit margins are in the 20 percent to 30 percent range.

hours due to treatment are just a few examples.¹³⁴ Out-of-pocket expenses for the patient and his/her family include drugs, home care, homemaking, alternative medicines, vitamins and supplements, family care, travel, parking, accommodations, and devices. According to a Canadian Study, average monthly out-of-pocket costs were \$213, with an additional \$372 for imputed travel costs, in 2005 Canadian dollars.¹³⁵ At year-end 2005, the U.S. dollar was worth 1.1686 (the lowest value of the year).¹³⁶ So the average monthly costs in U.S. 2005 dollars would have been \$182 and \$318 respectively, or \$223 and \$390 in December 2016 dollars per month, for an average of \$3,678 per year.

There are many costs not included in the direct and indirect costs listed above. AARP estimates that the average caregiver spent out-of-pocket, for family groceries, medicines, and other needs, an average of \$5,531 in 2007,¹³⁷ or \$6,402 in 2016 dollars. If a caretaker spends, on average, \$6,402 per year extra, the worker is likely to spend at least that much. However, because this study looks at both caretaker and ill worker extra spending, there may be some overlap in their reported expenditures, so calculations in this research make a conservative calculation of caretaker spending of half that amount, or \$3,201.

Children who do not go to college because they have to work to make up lost family income or because they have to take care of the injured or ill family member, are each likely to earn 36 percent less than a college graduate over their lifetime, a conservatively estimated \$230,541 in 2016 dollars.¹³⁸ In addition, a family struggling with medical issues may need federal safety net programs like food stamps, unemployment insurance (for the ill person and/or caretaker), and/or housing assistance. The mental health effects of one's own infirmities or those of a family member may require expenditures for psychotherapy. A person may lose the possibility of living independently. A caretaker may have to take leave without pay. A caretaker may have a lower Social Security retirement if there are periods of time with reduced income and thus lower Social Security deductions. Similarly, a rail worker may have lower contributions to Railroad Retirement, and thus a lower retirement income. As discussed, 80 percent of households with a family member with COPD are unable to maintain their pre-illness lifestyle.

Not counting third-party payments (from food stamps to Social Security disability), or reductions in pension benefits for victim and caregiver due to lower contributions, or a whole host of social/

¹³⁴ Cancer.Net, "Understanding the Costs Related to Cancer Care," <http://www.cancer.net/navigating-cancer-care/financial-considerations/understanding-costs-related-cancer-care>, June 2015, accessed September 12, 2017.

¹³⁵ Aaronson, N. et al, "Beyond treatment – Psychosocial and behavioral issues in cancer survivorship research and practice," *EJC Supplements*, 2014, <http://dx.doi.org/10.1016/j.ejcsup.2014.03.005>, accessed September 2016.

¹³⁶ Bank of England, "U.S. Dollar to Canadian Dollar Spot Exchange Rates for 2005 from the Bank of England," <https://www.poundsterlinglive.com/bank-of-england-spot/historical-spot-exchange-rates/usd/USD-to-CAD-2005>, accessed October 19, 2017.

¹³⁷ AARP, "Valuing the Invaluable..." p. 3.

¹³⁸ Shapiro, S., Ruttenberg, R., Leigh, P., "The Social Costs of Dangerous Products: An Empirical Investigation," *Cornell Journal of Law and Public Policy*, Vol 18, No 3, Summer 2009.

emotional costs, BMWED excess deaths only from COPD cost \$179 million. The cost per individual: close to \$140,000. (See Table 4 below.)

Table 4: Estimated Costs of COPD to Individuals and to the BMWED Community*		
Cost Category	Cost to the Individual	Cost to the BMWED Community (in million \$s)
<u>Direct and Indirect Costs</u> (as estimated by OSHA)	\$103,118	\$134.9
<u>Presenteeism</u> (12 days a year, assumed to be working on the job for 5 years with the disease)	\$13,405	\$17.5
<u>Unpaid Caretaker Wages</u> (at \$12.51/hour for 18 hours per week for 5 years, for 10% of the 3,364 excess deaths)	\$1,171	\$1.5
<u>Out-of-Pocket Caretaker Expenditures</u> (at \$6,402 per caregiver and 10% of excess cases, or 3,364, for five years)	\$3,201	\$4.2
<u>Out-of-Pocket Expenditures by the Worker for 5 years</u> (1/2 caretaker amount = \$3,201 x 5 years)	\$16,005	\$20.9
<i>TOTAL</i>	<i>\$136,900</i>	<i>\$179.0</i>

*These costs are spread across several groups: individuals and their families, employers, insurance companies, government entities, and society at large.

Sources: Calculations within this report

2. Non-Cancerous Chronic Kidney Disease

Maintenance-of-way workers have an increased risk of kidney disease. According to a recent Standardized Mortality Ratio (SMR) study,¹³⁹ for each male 18 to 64 years old in the general population who dies of nephritis, there is 2.5 times more risk of kidney disease mortality among BMWED members.¹⁴⁰ Exposure to occupational and environmental chemicals and silica dust from ballast that damage the kidneys put many maintenance-of-way workers at risk of kidney damage and chronic kidney disease.

Kidney health is critical for overall health. The kidneys clean waste and extra fluids from the body by filtering the blood. They also produce three hormones necessary for our bodies to function well. They produce erythropoietin (EPO) which leads bones to make red blood cells that carry oxygen and nutrients throughout the body. The kidneys also make renin which helps keep blood pressure normal. And, the kidneys make the active form of vitamin D, which is necessary for calcium to work to build bones. Finally, they keep our bodies chemically balanced.^{141,142} Although

¹³⁹ Goldsmith and Barlet.

¹⁴⁰ The SMR was based on data 1979-2014. Assumed in this report is that SMRs are the same for MOW workers currently active and on-the-job.

¹⁴¹ WebMD, "Your kidneys and how they work," n.d.a., <http://www.webmd.com/a-to-z-guides/function-kidneys#1>, accessed December 15, 2016.

¹⁴² National Kidney Foundation, "Top 5 Jobs Kidneys do," n.d.a., <https://www.kidney.org/kidneydisease/top-5-jobs-kidneys-do>, accessed December 15, 2016.

it is a progressive disease, most people do not know when they are in the early stages of chronic kidney disease, so it may seem to arise abruptly.

The first four stages of kidney disease, marked by reduced kidney function, are usually referred to as chronic kidney disease (CKD). As individuals progress through these four stages, they will likely suffer increasing numbers of health problems as toxins build up, bones weaken, and blood pressure rises. End-stage renal disease (ESRD) is diagnosed when the patient is in the fifth, or final, stage of kidney disease, with complete and permanent kidney failure.¹⁴³ According to the National Kidney Foundation, the average life expectancy for someone on dialysis is five to ten years, but it is very possible to live much longer, even twenty to thirty years.¹⁴⁴

a. Some Causes of Chronic Non-Cancerous Kidney Disease. Several heavy metals to which maintenance-of-way workers are frequently exposed cause kidney disease: lead, cadmium (welding), arsenic, mercury, toluene, solvents, and uranium.^{145, 146, 147} There is also growing evidence of many other environmental causes of CKD. Rubenstein et al.¹⁴⁸ estimate that at least 50 percent of patients with CKD had renal disease due to occupational or environmental factors.

Creosote can cause kidney damage by being inhaled, touched, or eaten.¹⁴⁹ Residue can be transferred to food, cigarettes, and drinks through ingestion or inhalation. Creosote was banned for individual use in 1986,¹⁵⁰ but commercial and industrial use requires only a certification, so it is still widely used as a preservative for wooden railroad ties. The FDA updated warnings about creosote in 1992, including a warning of its negative effects on kidneys.¹⁵¹

¹⁴³ U.S. Renal Data System (USRDS), *The 2016 Annual Data Report*, Volume 1: Chronic Kidney Disease in the United States, Introduction, 2016b, https://www.usrds.org/2016/view/v1_00.aspx accessed December 13, 2016.

¹⁴⁴ National Kidney Foundation website, “Dialysis,” <https://www.kidney.org/atoz/content/dialysisinfo>, accessed February 14, 2017.

¹⁴⁵ Sabath, E., Robles-Osorio, M.L. “Renal Health and the environment: heavy metal nephrotoxicity, abstract,” *Nefrologia*, 32(3), May 14, 2012, p. 279.

¹⁴⁶ Soderland, P. et al, “Chronic Kidney Disease Associated with Environmental Toxins and Exposures,” *Advances in Chronic Kidney Disease*, Vol 17, No 3, May 2010, pp. 255,258.

¹⁴⁷ Said, S., Hernandez, G., “Environmental Exposures, Socioeconomics, Disparities, and the Kidneys,” *Advances in Chronic Kidney Disease*, Vol 22, No 1, January 2015, p. 39.

¹⁴⁸ Rubinstein, S., Wang, C., Qu, W., “Occupational risk and chronic kidney disease: a population-based study in the United States adult population,” *International Journal of Nephrology and Renovascular Disease*, 6, 2013, p. 57.

¹⁴⁹ Yourlawyer.com, “Creosote side effects can be linked to liver damage lawsuits,” <http://www.yourlawyer.com/topics/overview/creosote>, accessed December 14, 2016.

¹⁵⁰ Levine, M., “Banned Wood Preservatives Still on Sale,” *LA Times*, December 21, 1986, http://articles.latimes.com/1986-12-21/local/me-4302_1_wood-preservatives, accessed December 15, 2016.

¹⁵¹ U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Agency for Toxic Substances and Disease Registry (updated 2016). “Public Health Statement for Creosote. 1.9 What recommendations has the federal government made to protect human health?” <https://www.atsdr.cdc.gov/phs/phs.asp?id=64&tid=18#book mark09>, accessed February 2017.

Exposure to silica dust is another workplace cause of kidney disease, one which has been recognized since the 1930s.¹⁵² Rail workers are frequently exposed to silica though breathing dust from the granite ballast along the tracks. Although the levels of silica dust to which one can be exposed (permissible exposure limits [PELs]) have been regulated by the Occupational Safety and Health Administration (OSHA) since the 1960s, the recent update (in 2016), “established a new PEL that is two to five times lower than the PELs that have been implemented by the railroad industry for the past 40 years,”¹⁵³ so any workers employed before 2016 have had what is now considered excess exposure to silica dust.

Some herbicides, including those with glyphosates, are associated with chronic kidney disease.¹⁵⁴ Herbicides are heavily used along railroad tracks to keep the right of way clear of vegetation. Glyphosate is a major component of Monsanto’s Roundup. In March 2015 the World Health Organization’s International Agency for Research on Cancer classified glyphosate as a probable human carcinogen. So, in addition to CKG, glyphosates are associated with non-Hodgkin lymphoma, renal tubule carcinoma, and other cancers are also associated with the chemical.

Occupational health physician Jay Brown¹⁵⁵ established a relational database (haz-map.com) with notes from textbooks and research reports on hazardous chemicals encountered in the workplace which cause disease and illness in workers. He summarizes the information from the database on materials which can reliably be said to cause acute renal failure, chronic renal failure or immune-mediated chronic renal failure. These chemicals include substances to which railroad workers may be exposed, such as lead, arsenic, chlorinated solvents, and petroleum distillates as well as mercury, carbon tetrachloride, and ethylene glycol. These have been closely linked with “acute or chronic renal failure” since the 1960s. In a study of North Carolina workers with and without CKD, Sponholtz et al.¹⁵⁶ found continued evidence that silica, dust, toluene, use of gasoline as a solvent or for cleaning, solvents, degreasers and other cleaning agents are all probable causes of kidney disease.

¹⁵² Doran & Murphy Law Firm, “OSHA’s Rule Further Limits Exposure to Silica in the Workplace,” 2016, <http://www.doranandmurphy.com/Railroad-Injury-Blog/2016/May/OSHAs-New-Rule-Further-Limits-Exposure-to-Silica.aspx>, accessed December 15, 2016.

¹⁵³ Ibid.

¹⁵⁴ Jayasumana, C. et al., “Drinking well water and occupational exposure to Herbicides is associated with chronic kidney disease in Padavi-Sripura, Sri Lanka,” *Environmental Health*, 2015. <https://ehjournal.biomedcentral.com/track/pdf/10.1186/1476-069X-14-6?site=ehjournal.biomedcentral.com>, accessed 2017.

¹⁵⁵ Brown, J., “Occupational Renal Diseases,” n.d., <http://www.haz-map.com/renal.htm>, accessed December 16, 2016.

¹⁵⁶ Sponholtz, T.R., Sandler, D.P., Parks, C.G., Applebaum, K.M., “Occupational exposures and chronic kidney disease: Possible associations with endotoxin and ultrafine particles,” *Am J Ind Med*, 59(1), 2016, pp. 1-11. doi: 10.1002/ajim.22541, 2016, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4715760/>, accessed December 12, 2016.

Those working in Transportation and Material Moving Occupations, were 4.7 times more likely to develop CKD than were controls.¹⁵⁷ Although working in transportation may be related to kidney disease via exposure to toxins, many of these occupations are thought to be associated with kidney disease through stress on the job. But how all of the possible factors related to chronic kidney disease interact is not yet clear.

Having chronic kidney disease makes one twice as likely to die when compared to those without CKD.¹⁵⁸ The prevalence of CKD has been increasing steadily. For every individual on dialysis in the U.S., there are 200 with stage 3 or 4 chronic kidney disease and nearly 5,000 with stage 1 or 2.¹⁵⁹

b. Economic and Social Impacts of Chronic Non-Cancerous Kidney Disease. Chronic kidney disease is expensive and MOW workers have a significantly higher risk of developing kidney disease than the general public. As already reported they are 2.5 times more likely to develop kidney disease than the same size cohort of men in the U.S. generally; perhaps as much as 4.7 times more likely).¹⁶⁰ As the disease progresses, individuals become increasingly impaired. An individual on dialysis has a significantly reduced quality of life. While there are treatments, the cost to taxpayers, since Medicare covers much of the cost of kidney disease, is high.

Economic Costs of Chronic Non-Cancerous Kidney Disease. According to Sullivan, the 2001 Institute for Health and Productivity Management (IHPM) database revealed that annual insurance claims for a patient with kidney disease were \$15,000 in stage 3, \$28,000 in stage 4, and \$70,000 and up in stage 5,¹⁶¹ or \$20,000, \$38,000, and \$95,000 respectively in 2016 dollars. People with chronic kidney disease were also much more likely to be hospitalized and to use home health and skilled nursing services than those with heart failure, diabetes, depression, cancer, or COPD. Furthermore, they were more likely than those with these other conditions to have two or more other chronic diseases.¹⁶² According to the U.S. Renal Data System,¹⁶³ inpatient/outpatient care for each kidney transplant patient cost \$158,138 in 2011, or \$168,731 in 2016 dollars. Dialysis patients alone cost on average nearly \$32,000 per year, or \$34,144 in 2016 dollars.

¹⁵⁷ Rubinstein, S., Wang, C., Qu, W., “Occupational risk and chronic kidney disease: a population-based study in the United States adult population,” *International Journal of Nephrology and Renovascular Disease*, 6, 2013.

¹⁵⁸ U.S. Renal Data System (USRDS), *The 2016 Annual Data Report, Volume 1: Chronic Kidney Disease in the United States*, 2016a, <https://www.usrds.org/adr.aspx>, accessed December 13, 2016.

¹⁵⁹ Soderland, P. et al., “Chronic Kidney Disease Associated with Environmental Toxins and Exposures,” *Advances in Chronic Kidney Disease*, Vol 17, No 3, May 2010, p. 254.

¹⁶⁰ Rubinstein, et al.

¹⁶¹ Sullivan, S., “Employer Challenges with the Chronic Kidney Disease Population”, *J Manag Care Pharm*, 13(9 suppl D), December 2007, S19-21.

¹⁶² Schneider, K.M. et al., “Health Quality Life Outcomes,” September 8, 2009, in <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2748070/>, accessed February 14, 2017.

¹⁶³ United States Renal Data System, “Costs of ESRD,” Chapter 11, *2013 Atlas of CKD and ESRD*, 2013, <https://www.usrds.org/atlas13.aspx>, accessed March 19, 2017.

According to an actuarial report by Bentley,¹⁶⁴ the average 2014 kidney transplant costs were \$334,300 per patient, or \$338,919, in 2016 dollars, including pre-transplant, procurement, hospital time, post-transplant discharge, and out-patient prescription medication. Additional direct costs include physical therapy and rehabilitation. Indirect costs associated with transplants include lodging and food for family members while the patient is hospitalized – and for family and patient while awaiting transplant, physical therapy, transportation to and from the transplant center, child care, and lost wages.

Those with permanent kidney failure are eligible for Medicare^{165,166} and railroad workers are eligible for disability payments under the Railroad Retirement Board.¹⁶⁷ The RRB in 2015 reported that railroad workers received average disability payments of almost \$2,870 a month, a value of \$2,930 in 2016 dollars,¹⁶⁸ much more than the average Social Security disability payment of \$1,235. Compensated service includes regulated compensation for active service as well as pay for time lost, wage continuation payments, certain employee protection payments, and any other payment for which the employee will receive additional creditable service. But the RRB does not report how many maintenance-of-way workers are receiving disability because of CKD or end stage renal disease.

In addition to medical costs paid by Medicare, there are drug costs covered by Part D of Medicare for the 71 percent of CKD patients who are enrolled. Medication costs are more than two times greater for CKD patients than for general Medicare patients.¹⁶⁹

OSHA in its Safety Pays Estimator¹⁷⁰ calculates both the direct and indirect costs of occupational disease, finding occupational disease direct costs of \$49,104 per case and indirect costs of \$54,014, for a total cost of \$103,118 per case of occupational disease. This is probably a low estimate for chronic kidney disease. The Safety Pays Estimator also estimates the amount of sales a company or industry would have to earn to make up for those costs. Assuming a 20 percent to 30 percent

¹⁶⁴ Bentley, T. S., “2014 U.S. organ and tissue transplant cost estimates and discussion,” Milliman Research Report, December 2014, p, 5, http://www.milliman.com/uploadedFiles/insight/Research/health-rr/1938HDP_2014_1230.pdf, accessed 2016.

¹⁶⁵ U.S. Railroad Retirement Board, “Medicare for Railroad Workers and their Families,” n.d., <https://www.rrb.gov/pdf/opa/rb20.pdf>, accessed December 12, 2016.

¹⁶⁶ Social Security Administration, “What is Medicare and who can get it?” n.d.a., <https://faq.ssa.gov/ics/support/KBAnswer.asp?questionID=3771&hitOffset=50+41&docID=5465>, accessed December 14, 2016.

¹⁶⁷ U.S. Railroad Retirement Board, “Disability Annuities for Railroad Employees,” October 2015. https://www.rrb.gov/opa/qa/pub_1510.asp, accessed December 18, 2016. [no longer available]

¹⁶⁸ Railroad Retirement Board, “Q&A: Disability Annuities for Railroad Employees,” October 2015, <https://www.rrb.gov/NewsRoom/NewsReleases/Q%26A%3A%20Disability%20Annuities%20for%20Railroad%20Employees>, accessed November 28, 2017.

¹⁶⁹ U.S. Renal Data System (USRDS), *The 2016 Annual Data Report, Volume 1: Chronic Kidney Disease in the United States*, Chapter 7: Medicare Part D Prescription Drug Coverage in Patients with CKD, 2016g, https://www.usrds.org/2016/view/v1_07.aspx, accessed December 13, 2016.

¹⁷⁰ U.S. Department of Labor, Occupational Safety and Health Administration, “OSHA’s Safety Pays Program...”

profit margin, just to make up for the cost of excess CKD deaths among maintenance-of-way employees, the railroad industry would need increased sales of more than \$515,000 per case at a 20 percent profit margin and almost \$344,000 at a 30 percent profit margin. Using these numbers, the sales needed by the railroad industry, just to make up for the cost of 3,255 excess CKDs among active maintenance-of-way employees would be \$1.1 billion to \$1.7 billion.¹⁷¹

Social Costs of Chronic Non-Cancerous Kidney Disease. A study by Wyld et al.¹⁷² analyzes the costs of chronic kidney disease as it affects society. The study looks at data from CKD costs in Australia in 2004-2005, and while the country and social programs are different from the U.S., the severe social burdens brought on by severe kidney disease are similar. Wyld's measure of the cost to society is the amount of money spent on government subsidies such as disability, "Veterans' Affairs pension, mobility allowance, sickness allowance and unemployment benefits." Overall, they found that people with CKD claimed 50 percent more government subsidies than those without. The data from the U.S. Renal Data System (USRDS) already presented show high costs to the U.S. taxpayer as well.¹⁷³

Neither Wyld et al.'s work¹⁷⁴ nor that of others includes costs assumed by families such as transportation to doctors and hospitals, living costs for the family when they are away from home to take the ill family member for doctor and hospital visits, any extra help needed in the home or for day care so other family members can work and go to school, or any special foods needed. Nor does it include lost job or educational opportunities, or lost pay family members may incur to support or transport the ill family member. Costs to the community are also not easy to quantify and are almost never included in the list of costs, much less estimated. What happens to religious and community organizations when a person cannot volunteer or participate in community activities? When whole families cannot participate because they lack time or money or energy?

c. Costs of Chronic Non-Cancerous Kidney Disease to the BMWED Membership and to Individuals. There are 31 million adults in the U.S. with chronic kidney disease.¹⁷⁵ With 249 million adults in the U.S., that means 12.4 percent of U.S. adults have chronic kidney disease. Nearly half of those who have end stage renal disease (ESRD) are of working age;¹⁷⁶ i.e., 6.2 percent. This 6.2 percent would suggest that among active BMWED members, 2,170 would have

¹⁷¹ These costs are societal and have not been allocated to individual parties or groups of parties because of the complexities of payment and third-party payment. This is especially the case of allocation of burden among employers, private insurers, workers compensation, and Federal Employers Liability Act (FELA)-sanctioned legal compensation.

¹⁷² Wyld, M.L., Lee, C.M., Zhuo, X., et al., "Cost to government and society of chronic kidney disease stage 1–5: a national cohort study," *Intern Med J*, 45, 2015, pp. 741–7.

¹⁷³ U.S. Renal Data System (USRDS), *The 2016 Annual Data Report, Volume 1*.

¹⁷⁴ Wyld, Lee, Zhuo et al.

¹⁷⁵ American Kidney Fund, "2015 Kidney Disease Statistics," <http://www.kidneyfund.org/assets/pdf/kidney-disease-statistics.pdf>, accessed November 26, 2017.

¹⁷⁶ Muehrer, R. et al., "Factors Affecting Employment at Initiation of Dialysis," *Clin J Am Soc Nephrol*, 6(3), March 2011, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3082405>, accessed January 24, 2018.

chronic kidney disease.¹⁷⁷ But an SMR study in 2017,¹⁷⁸ found that an adult male member of BMWED was 2.5 times more likely to die of nephritis, suggesting that instead of 2,170, there are 5,425 BMWED members who have chronic kidney disease. Furthermore, the number of people with the disease is probably higher since not everyone with the disease dies of that illness – large numbers may have cause of death listed as cardiac, septicemia, or other disease. For example, heart disease is the major cause of death for all people with CKD.¹⁷⁹ If one uses Rubenstein’s estimates of disease being 4.7 times expected, then instead of 2,170 cases among BMWED members, there would be 10,199. But to be conservative, the Goldsmith findings are used in calculations in this paper. This paper, therefore, estimates that there are 3,255 more BMWED members sick with chronic kidney disease than would be expected.¹⁸⁰

According to the Occupational Safety and Health Administration,¹⁸¹ each occupational disease costs, in direct plus indirect costs, \$103,118 – a low estimate if someone were to receive a kidney transplant, the price of which alone can range from an estimated \$169,000¹⁸² to \$338,919 (from pre-surgery triage through the first six months post-surgery).¹⁸³ And not included in these medical costs are such additional medical services as physical therapy and rehabilitation. On top of direct medical costs are all the indirect costs. And besides the normally expected ones, there may be significant out-of-pocket expenses if an individual needs to travel for dialysis or buy meals and lodging while awaiting a kidney for transplant. Based on insurance claims studied by the Institute for Health and Productivity Management,¹⁸⁴ in 2016 dollars, the direct cost of stage 3 kidney disease is approximately \$20,000 a year; stage 4, \$38,000; and stage 5, \$95,000 and up, substantially higher than the OSHA estimate.

Railroad retirement disability paid \$2,870 per month in 2015, or \$2,930 in 2016 dollars.¹⁸⁵ If an individual on dialysis lives for five to 20 years on disability (the average for someone on

¹⁷⁷ Some estimate the rate to be higher – 13-16% according to Chowdhury et al. (See bibliography for full source.)

¹⁷⁸ Goldsmith and Barlet.

¹⁷⁹ National Kidney Foundation, “About Chronic Kidney Disease: A to Z Health Guide,” <https://www.kidney.org/atoz/content/about-chronic-kidney-disease>, accessed January 24, 2018.

¹⁸⁰ $5,425 - 2,170 = 3,255$. The SMR was based on data from 1979-2014. Assumed in this report is that SMRs are the same for MOW workers currently active and on-the-job.

¹⁸¹ U.S. Department of Labor, Occupational Safety and Health Administration, “OSHA’s Safety Pays Program...”

¹⁸² United States Renal Data System, “Costs of ESRD,” Chapter 11, *2013 Atlas of CKD and ESRD*, 2013, <https://www.usrds.org/atlas13.aspx>, accessed March 19, 2017.

¹⁸³ Bentley, T. S., “2014 U.S. organ and tissue transplant cost estimates and discussion,” Milliman Research Report, December 2014, p. 5, http://www.milliman.com/uploadedFiles/insight/Research/health-rr/1938HDP_2014_1230.pdf, accessed 2016.

¹⁸⁴ Sullivan, S., “Employer Challenges with the Chronic Kidney Disease Population”, *J Manag Care Pharm*, 13(9 suppl D), December 2007, S19-21.

¹⁸⁵ Railroad Retirement Board, “Q&A: Disability Annuities for Railroad Employees,” October 2015, <https://www.rrb.gov/NewsRoom/NewsReleases/Q%26A%3A%20Disability%20Annuities%20for%20Railroad%20Employees>, accessed November 28, 2017.

dialysis,¹⁸⁶ and dialysis clearly being an indication of someone on disability), then the cost to the Railroad Retirement Board would be \$35,160 a year, or \$175,800 to \$703,200 for just one individual over the last years of his/her life.

If one uses the conservative OSHA estimate of \$103,118, then the 3,255 excess deaths, of current BMWED members currently with CKD, would suggest costs, while the individual was still alive, of nearly \$446 million in the BMWED community alone. If the railroad industry were to take financial responsibility for these excess illnesses likely caused by work exposures, then railroad companies would need more than a billion dollars in additional sales to pay for this economic burden. (\$1.1 billion to \$1.7 billion at a profit margin of 20 percent to 30 percent profit margin.) If one only counts the amount that RRB disability is higher than Social Security (\$2,930 vs. \$1,235¹⁸⁷), then the additional cost for disability payments would be \$1,695 a month, or \$20,340 per person per year, for \$101,700 to \$406,800 per person over their five to twenty years of additional expected life. Saving just half these BMWED members from chronic kidney disease, could save hundreds of millions of dollars in disability payments. To summarize, the conservative average lifetime cost per person for chronic kidney disease is estimated to be approximately \$140,000. The total cost for BMWED “excess deaths,” is estimated to be \$445.5 million. These costs are summarized in Table 5:

Table 5: Estimated Costs of CKD to Individuals and to the BMWED Community*		
Cost Category	Average Cost to the Individual	Cost to the BMWED Community (in million \$s)
<u>Direct and Indirect Costs</u> (as estimated by OSHA)	\$103,118	\$335.6
<u>Presenteeism</u> (12 days a year, assumed to be working on the job for 5 years with the disease)	\$13,405	\$43.6
<u>Unpaid Caretaker Wages</u> (at \$12.51/hour for 18 hours per week for 5 years, for 10% of the 6,460 excess deaths)	\$1,171	\$3.8
<u>Out-of-Pocket Caretaker Expenditures</u> (at \$6,402 per caregiver and 10% of excess cases, or 6,460, for 5 years)	\$3,201	\$10.4
<u>Out-of-Pocket Expenditures by the Worker for 5 years</u> (1/2 caretaker amount = \$3,201 x 5 years)	\$16,005	\$52.1
<i>TOTAL</i>	<i>\$136,900</i>	<i>\$445.5</i>

*These costs are spread across several groups: individuals and their families, employers, insurance companies, government entities, and society at large.

Sources: Calculations within this report.

3. Cancer

The American Cancer Society links chemicals, dusts, and radiation exposure at work to cancer, and concludes that, “All cancers of occupational origin are preventable.”¹⁸⁸ Specifically, it links asbestos, radon, soot, silica, diesel exhaust, and radioactive ores to lung cancer; herbicides and

¹⁸⁶ National Kidney Foundation website, “Dialysis,” <https://www.kidney.org/atoz/content/dialysisinfo>, accessed February 14, 2017.

¹⁸⁷ Railroad Retirement Board, “Q&A: Disability Annuities...”

¹⁸⁸ American Cancer Society, “Occupation and Cancer,” January 2015.

radiation to lymphatic and hematopoietic cancer; sunlight to skin and lip cancer; radiation to soft-tissue sarcoma.¹⁸⁹ Diesel exhaust is also associated with bladder and laryngeal cancers, and silica with esophageal cancer.¹⁹⁰ According to another study, “a significant proportion of lung cancers is attributable to occupational carcinogens.”¹⁹¹ Even chromosome aberrations in the blood have been linked to carcinogens in occupational settings, according to a study focusing on rail workers which found abnormalities in rail workers exposed to complex chemical mixtures transported by train.¹⁹² Maintenance-of-way workers, exposed to many of these carcinogens, are at excess risk of developing cancer – with a standardized mortality ratio of 1.79 overall, but as high as 2.17 for pancreatic cancer and 2.36 for liver cancer.¹⁹³

“Rail workers are among the most likely to be exposed to cancer causing materials and substances in the course of their jobs.”¹⁹⁴ A Finnish study linked cumulative exposure to chemical agents to cancer in railway traffic supervisors.¹⁹⁵ Maintenance-of-way workers develop many types of cancers, often due, at least in part, to their work-life exposures. According to one survey respondent, “I have been to so many funerals of past work mates and every single one was cancer. A large portion were mesothelioma. I believe this will be my lot too.”

Soot and tar, as well as untreated and mildly treated mineral oils, are human carcinogens, according to the International Agency for Research on Cancer.¹⁹⁶ Creosote is a probable human carcinogen and associated with skin cancer (as well as with skin burning and lung irritation).¹⁹⁷ Creosote is also known to contain poly-nuclear aromatic hydrocarbons (PAHs), which are known human

¹⁸⁹ Ibid.

¹⁹⁰ Haz-Map, “Occupational Cancer,” January 2015, <http://www.haz-map.com/cancer.htm>, accessed July 27, 2015.

¹⁹¹ De Matteis, S., Consonni, D., Bertazzi, P., “Exposure to occupational carcinogens and lung cancer risk. Evolution of epidemiological estimates of attributable fraction,” *Acta Bio-Medica: Atenei Parmensis*, 79 Suppl 1, 2008, https://air.unimi.it/retrieve/handle/2434/54733/9262/ActaBiomed2008_79S1-34_Exposure-DeMatteis.pdf, p. 34.

¹⁹² Catalan, J., et al., “Chromosomal Aberrations in Railroad Transit Workers: Effect of Genetic Polymorphisms,” *Environmental and Molecular Mutagenesis*, 50, 2009, p. 304.

¹⁹³ Goldsmith and Barlet.

¹⁹⁴ Morey, K. (chair Institute of Occupational Safety and Health’s Railway Group, UK), “Time to tackle occupational cancer,” November 25, 2015, <http://www.railpro.co.uk/railpro-magazine/december-2015-issue/time-to-tackle-occupational-cancers>, accessed July 3, 2016.

¹⁹⁵ Guo, J. et. al., “Testicular cancer, occupation and exposure to chemical agents among Finnish men in 1971-1995,” *Cancer Causes and Control*, 16, 2005, p. 97.

¹⁹⁶ Mastrangelo, G., Fadda, E., Marzia, V., “Polycyclic Aromatic Hydrocarbons and Cancer in Man,” *Environmental Health Perspectives*, Vol 104, No 11, November 1996, p. 1166.

¹⁹⁷ U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Agency for Toxic Substances and Disease Registry, “Creosote Health Facts,” November 2006, [https://www.atsdr.cdc.gov/sites/KerrMcGee/docs/Creosote%20Health%20Effects%20\(Tronox\).pdf](https://www.atsdr.cdc.gov/sites/KerrMcGee/docs/Creosote%20Health%20Effects%20(Tronox).pdf), accessed January 1, 2017.

carcinogens.¹⁹⁸ Further, creosote has mutagenic effects in vitro – posing harm to the healthy development of fetuses.¹⁹⁹

Herbicide exposure, especially a combination of amitrole and phenoxy acids have been shown to be associated with an excess of tumors in Swedish rail workers.²⁰⁰ The International Agency for Research on Cancer (IARC) identifies glyphosate as a probable carcinogen and 2,4-D as a possible carcinogen.²⁰¹ The Center for Food Safety questions the categorization of 2,4-D herbicides as only possible human carcinogens because research has often found it to be associated with non-Hodgkin's lymphoma and over 1,500 formulations of sprays use 2,4-D as the main ingredient.²⁰² Herbicides are applied to tens of thousands of miles of track in the U.S., and railroads leave it up to their respective contractors to determine which herbicides they use.²⁰³

a. Economic and Social Impacts of Cancer.

The economic and social costs of cancer are extremely high, but even more so among MOW workers. Based on a standardized mortality ratio study in 2017,²⁰⁴ BMWED members are 1.79 times more likely to die of cancer as men aged 18 to 64 generally. And the risk of death is high for specific types of cancer:

- | | |
|------------------------------|------------------------------|
| ✓ 1.82 for esophageal cancer | ✓ 1.93 for prostate cancer |
| ✓ 2.06 for stomach cancer | ✓ 1.75 for kidney cancer |
| ✓ 1.99 for colorectal cancer | ✓ 1.95 for bladder cancer |
| ✓ 2.36 for liver cancer | ✓ 1.88 for Hodgkin's disease |
| ✓ 2.17 for pancreatic cancer | ✓ 1.96 for leukemia. |
| ✓ 1.82 for lung cancer | |

¹⁹⁸ Rincon Consultants, Inc., "Monterey Bay Sanctuary Scenic Train Network Master Plan, Final Environmental Impact Report, Prepared for Santa Cruz County Regional Transportation Commission, California," Section 4.8 Hazards and Hazardous Materials, Certified November 7, 2013, p. 4.8-1, <https://sccrtc.org/wp-content/uploads/2013/05/MBSST-Network-Master-Plan-FEIR.pdf>, accessed December 2016.

¹⁹⁹ U.S. Environmental Protection Agency, "Reregistration Eligibility Decision (RED) Document for Creosote," Case 0139, EPA 739-R-08-007, September 25, 2008, https://www3.epa.gov/pesticides/chem_search/reg_actions/reregistration/red_PC-025004_25-Sep-08.pdf, accessed January 22, 2017.

²⁰⁰ Axelson, O. et al, "Herbicide exposure and tumor mortality: An updated epidemiologic investigation on Swedish railroad workers," *Scand j work environ health*, 6, 1980, p. 73.

²⁰¹ International Agency for Research on Cancer (IARC), "IARC Monographs evaluate DDT, lindane, and 2,4-D," Press Release 236, June 23, 2015, https://www.iarc.fr/en/media-centre/pr/2015/pdfs/pr236_E.pdf, accessed October 2016.

²⁰² Center for Food Safety, "World Health Organization Determines that Herbicide 2,4-D May Cause Cancer," June 25, 2015, <http://www.commondreams.org/newswire/2015/06/25/world-health-organization-determines-major-herbicide-24-d-may-cause-cancer>, accessed February 14, 2017.

²⁰³ Progressive Railroading, "Vegetation management: Railroads are pulling out all the stops," *Progressive Railroading*, February 2008, <http://www.progressiverailroading.com/mow/article/Vegetation-management-Railroads-are-pulling-out-all-the-stops--15029>, accessed October 7, 2015.

²⁰⁴ Goldsmith and Barlet.

Economic Costs of Cancer. National expenditures for cancer care in the United States totaled nearly \$125 billion in 2010 and could reach \$156 billion by 2020.²⁰⁵ Some estimates showed an increase between 2010 and 2020 of 39 percent, to \$173 billion a year.²⁰⁶ Preventing cancer is clearly in the economic interest of the nation, as well as in the health interest of citizens.

The average costs of cancer, from diagnosis on, vary by type. Most expensive of 13 major types of cancer are pancreatic cancer at \$318,000 and brain cancer at \$285,000. (See Table 6.) Others range from \$77,000 for melanoma, \$94,000 for prostate cancer, and \$180,000 for lung cancer treatment.²⁰⁷ It is initial treatment and last year of life care, that are most expensive, with continuing care less costly (though this area is showing a growing cost because more and more cancer patients are living longer and because pharmaceutical treatments are becoming more costly).

Table 6: Annualized Mean Net Costs of Care for Men with Cancer - Initial Treatment, Continuing Treatment, and Last Year of Life, 2010 and 2016 Dollars					
Site	Initial	Continuing	Last Year of Life	Total in 2010 Dollars	Total in 2016 Dollars
Bladder	\$20,960	\$4,677	\$75,772	\$101,409	\$111,705
Brain	115,250	9434	134,244	258,928	285,217
Colorectal	51,812	4,595	85,671	142,078	156,503
Esophagus	79,822	6,450	103,742	190,014	209,306
Head/Neck	39,179	4,001	83,662	126,842	139,720
Kidney	38,374	6,018	78,082	122,474	134,909
Leukemia	36,036	10,249	133,183	179,468	197,689
Lung	60,885	7,591	95,318	163,794	180,424
Lymphoma	60,701	9,337	116,596	186,634	205,583
Melanoma	5,437	1,951	62,436	69,824	76,913
Pancreas	94,092	11,697	113,115	288,728	318,042
Prostate	19,710	3,201	62,242	85,153	93,798
Stomach	78,453	4,282	107,130	189,865	219,056

Source: Based on data from the National Cancer Institute and the Bureau of Labor Statistics, CPI Inflation Calculator

²⁰⁵ National Cancer Institute, “Statistics at a Glance: The Burden of Cancer in the United States,” 2016, <https://www.cancer.gov/about-cancer/understanding/statistics>, accessed February 22, 2017.

²⁰⁶ Mariotto, A.G., Yabroff, K.R. et al., “Projections of the Cost of Cancer Care in the United States: 2010-2010,” *Journal of the National Cancer Institute*, 103(2), January 2011, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3107566/>, accessed September 12, 2017. [Link no longer working.]

²⁰⁷ U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute, “Cancer Prevalence and Cost of Care Projections: Annualized Mean Net Costs of Care,” <https://costprojections.cancer.gov/annual.costs.html>, accessed September 12, 2017.

For these 13 types of cancer, the simple, unweighted average cost for men for a medical cancer treatment is \$179,143, significantly higher than the OSHA estimate of \$129,624.²⁰⁸ OSHA's indirect cost estimates for cancer are \$142,586. If the same relationship of indirect to direct were applied to the National Cancer Institute estimates, the indirect costs would be \$197,077 or \$376,220 per cancer patient vs. the OSHA estimate of \$272,210.

Indirect Economic Costs of Cancer. Cancer can have a profound impact on the earnings of the patient and the patient's family. A study in the United Kingdom²⁰⁹ found that 57 percent of cancer survivors who were working when diagnosed, had to leave their job or change roles as a result of their illness. Annual earnings fell by 40 percent within two years and stayed low. Total family income fell by 20 percent for at least four years. And, in most cases, economic outcomes did not return to their pre-diagnosis levels.²¹⁰

Cancer may limit one's employment possibilities thereby also limiting, for many, their access to health insurance. Family caregivers may no longer be able to sustain previous employment or may have increased absenteeism, yet the need for employment may be even greater, not just to provide income but also for health insurance coverage and pharmaceutical costs. Drug costs are rising as new targeted therapies reach the market, with many as much as \$9,000, \$16,000, or even \$30,000 a month or more, and cost sharing for drug therapy for those with insurance is typically 20 percent.²¹¹

Indirect costs are estimated to be at least as much as direct medical costs.²¹² Many daily living costs increase with long-term illness and treatment—lower income when missing work hours due to treatment just one example.²¹³ Out-of-pocket expenses for the patient and his/her family include drugs, home care, homemaking, alternative medicines, vitamins and supplements, family care, travel, parking, accommodations, and devices. One study showed higher out-of-pocket costs per cancer patient, both direct and indirect at \$5,400 for a three-month time period, in 1992 dollars, or \$9,238 in 2016 dollars. Of this, \$2,433 per month²¹⁴ (or \$4,240 in 2016 dollars), or nearly half, was from lost wages. This suggests an annual out-of-pocket expenditure for cancer patients and

²⁰⁸ U.S. Department of Labor, Occupational Safety and Health Administration, "OSHA's Safety Pays Program..."

²⁰⁹ Wilson, B., "Work after cancer: what are the options and how can employers help?", *The Guardian*, April 9, 2014, <https://www.theguardian.com/society/2014/apr/09/work-after-cancer-options-employers>, accessed January 24, 2018.

²¹⁰ Zajacova, A. et al., "Employment and Income Losses Among Cancer Survivors: Estimates from a National Longitudinal Survey of American Families," *Cancer*, DOI: 10.1002/cncr.29510, March 2015, p. 1.

²¹¹ Yabroff, K.R., Lund, J. et al., "Economic Burden of Cancer in the US: Estimates, Projections, and Future Research," DOI: 10.1158/1055-9965.EPI-11-0650, October 2012, U.S. Department of Health and Human Services, HHS Public Access, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3191884/>, accessed September 12, 2017.

²¹² Ibid.

²¹³ Cancer.Net.

²¹⁴ Stommel et al. in Fortner, B. et al., "Description and Predictors of Direct and Indirect Costs of Pain Reported by Cancer Patients," *Journal of Pain and Symptom Management*, Vol 25, No 1, January 2003, p. 11.

their families of \$25,440 per year.²¹⁵ Yet another study shows that more than 10 percent of cancer patients have annual out-of-pocket costs that are higher than \$18,585, and 5 percent have costs that exceed \$35,660, in 2006 dollars,²¹⁶ or \$22,235 and \$42,663 in 2016 dollars.

According to estimates by Tangka et al., cancer leads to substantial numbers of lost work days each year – on average 6.1 days per case. Nearly half of those diagnosed with cancer (46.8 percent) were people of working age, under 65 years old. This suggests national costs of absenteeism, in 2010 dollars, of \$14.9 million to \$915.9 million annually, with a median of \$115.9 million. The cost of lost productivity from premature deaths attributed to cancer was \$123 billion and expected to rise to \$147.6 billion by 2020. Absenteeism was approximately 6.5 percent of premature cancer mortality cost,²¹⁷ that is 6.5 percent of \$135.5 billion in 2016 dollars, or \$8.8 billion.

Cancer and its treatments lead to the loss of economic resources and opportunities, not only for patients, but also for their families, employers, and society overall,²¹⁸ as well as a reduction in the government tax base. There are monetary losses from time spent receiving medical care, out-of-pocket expenditures by patients and their families and their caregivers, time lost from work, and lost productivity from premature death.

In 2009 the national internet-based Harris Interactive Chronic Illness Panel selected a random sample of people with chronic diseases and found that, even among these respondents who were better off than those in the overall panel, most (41 percent to 66 percent) had had trouble affording their medications and had either cut back on medicines, omitted medicines, cut back on basic needs, or incurred credit card debt in order to pay for their medicines. Furthermore, patients reported that the economic recession at the time had made it more likely that they would forego medicines for financial reasons.²¹⁹

Sixty percent of the economic burden of cancer is in non-health care areas, much of it in lost productivity at the workplace.²²⁰ Overall cancer costs estimated by the National Institutes of Health (NIH) were \$226.8 billion in 2007 -- \$103.8 billion for direct medical costs and \$123 billion for indirect costs. But these numbers do not include absences among survivors, a cost of another \$8.1 billion, or \$8.5 billion in 2016 dollars, which need to be added to the NIH cost estimates.²²¹

²¹⁵ \$2,220 x 12 = \$25,440.

²¹⁶ Goldman, D., G. Joyce, G. Lawless, W. Crown, and V. Willey. Benefit Design and Specialty Drug Use. *Health Aff*, 2006; 25(5): 1319.full in Alliance for Aging Research, “The Silver Book: Cancer,” http://www.silverbook.org/wp-content/uploads/2015/06/Silver-Book_Cancer_Fact-Sheet.pdf, accessed November 30, 2017.

²¹⁷ Tangka, F. et al., p. 1015.

²¹⁸ Yabroff, et al.

²¹⁹ Piette, J. et al., p. 187.

²²⁰ Aaronson, N. et al., “Beyond treatment – Psychosocial and behavioral issues in cancer survivorship research and practice,” *EJC Supplements*, 2014, <http://dx.doi.org/10.1016/j.ejcsup.2014.03.005>, accessed September 2016.

²²¹ Tangka, F. et al., p. 1017.

OSHA in its Safety Pays Estimator²²² estimates both the direct and indirect costs of cancer, finding the direct costs at \$129,624 and the indirect costs at \$142,586, for a total per case of \$272,210.

The amount of sales needed to pay for each case is \$907,000 to \$1,361,000 if the profit margin in the rail industry is 20 percent to 30 percent, for a total of \$685 million to \$1.0 billion for the 755 excess cancer deaths among current active maintenance-of-way workers who currently have cancer.

Social Costs of Cancer. As cancer increasingly becomes a chronic disease rather than a short-term death sentence, patients are more interested not only in surviving, but also in the quality of that survival.²²³ CDC and NCI data²²⁴ indicate that over 64 percent of men, 1988-2013, survived cancer for at least ten years.

Cancer can have a negative impact on the quality of a patient's daily life in many ways. Surviving cancer is not the end of the disease's impacts. Cognitive impairment can last for years after treatment is finished.²²⁵ There may be pain, fatigue, psychological distress, and problems with workforce participation.²²⁶ Chronic pain can be long-lasting, resulting from both tissue damaged by the cancer and treatment-related toxic damage. Depression often accompanies cancer and affects both quality of life and the trajectory of the illness.²²⁷ In fact depression is a comorbid and disabling problem that affects 15 percent to 25 percent of cancer patients.²²⁸

Cancer significantly affects all members of the family. Serious illness or death of a parent are two of the most severe things that can affect a child.²²⁹ Impaired parental health is strongly associated

²²² U.S. Department of Labor, Occupational Safety and Health Administration, "OSHA's Safety Pays Program," <https://www.osha.gov/dcsp/smallbusiness/safetypays/estimator.html> accessed March 16, 2017.

²²³ Naik, A. et al., "The effects of age, education, and treatment on physical, sexual and body concern symptoms among multimorbid, colorectal cancer survivors," *Journal of Geriatric Oncology*, 6, 2015, p. 302, <http://dx.doi.org/10.1016/j.jgo.2015.04.001>, accessed August 2016.

²²⁴ U.S. Department of Health and Human Services, Centers for Disease Control and Prevention and the National Cancer Institute, "Surveillance, Epidemiology, and End Results Program," <https://seer.cancer.gov/faststats/selections.php?#Output>, accessed January 24, 2018.

²²⁵ Wang, L., et al., "Reduced Prefrontal Activation During Working and Long-Term Memory Tasks and Impaired Patient-Reported Cognition Among Cancer Survivors Postchemotherapy Compared with Healthy Controls," *Cancer*, DOI: 10.1002/cncr.29737, 2015, p. 1.

²²⁶ Aaronson, N. et al., "Beyond treatment – Psychosocial and behavioral issues in cancer survivorship research and practice," *EJC Supplements*, 2014, <http://dx.doi.org/10.1016/j.ejcsup.2014.03.005>, accessed September 2016.

²²⁷ Mayr, M., Roland, S., "Pancreatic cancer and depression: myth and truth," *Cancer*, BioMed Central, 2010.

²²⁸ U.S. Department of Health and Human Services, National Institutes of Health, "Depression - for health professionals," <http://www.cancer.gov/about-cancer/coping/feelings/depression-hp-pdq>, accessed May 27, 2015.

²²⁹ Howell, K. et al., "Children Facing Parental Cancer Versus Parental Death: The Buffering Effects of Positive Parenting and Emotional Expression," *J Child Fam Stud*, April 2015, DOI 10.1007/s10826-015-0198-3.

with psychosocial problems in their teenagers.²³⁰ Cancer patients and their partners have a higher risk of mental disorders, cardiovascular diseases, and suicide.²³¹ Approximately 14 percent of cancer patients live with their minor children, and children (under 18) of cancer patients have an increased risk for death from any cause.²³² As for adult children, Teixeira and Pereira found many traumatized by the caregiving experience and presenting both physical and psychological symptoms – some similar to PTSD.²³³

Close to one-third of cancer survivors experience limitations in their ability to perform activities of daily living. Thirty-five percent of all men who were cancer survivors made changes in their work because of their cancer.²³⁴ In one study,²³⁵ 42 percent of cancer-surviving participants reported a significant financial burden from their cancer and as a result:

- 19 percent only partially filled a prescription
- 20 percent took less than the prescribed amount of medication
- 24 percent avoided filling prescriptions
- 46 percent used their savings to help cover out-of-pocket expenses
- 46 percent reduced spending on food and clothing
- 68 percent cut back on leisure activities.

b. Costs of Cancer to the BMWED Membership and to Individuals. Active BMWED members are estimated to have died at 1.79 times the rate in the general male population. If there are approximately 15 million adults currently with some form of cancer in the U.S., that is 6.02 percent of the 249 million adult population. And 45.4 percent of new cases were individuals age 20-64,²³⁶ or 2.73 percent of the population. Therefore, among active BMWED members, if MOW

²³⁰ Jeppesen, E. et al., “Does a parental history of cancer moderate the associations between impaired health status in parents and psychosocial problems in teenagers: a HUNT study,” *Cancer Medicine*, 3(4), 2014, p. 919, DOI: 10.1002/cam4.245.

²³¹ Chen, R. et al., “Parental cancer diagnosis and child mortality – A population-based cohort study in Sweden,” *Cancer Epidemiology*, 39, 2015, p. 79, <http://dx.doi.org/10.1016/j.canep.2014.11.011>, accessed February 2016.

²³² Ibid.

²³³ Teixeira, R., Pereira, M., “Psychological morbidity and autonomic reactivity to emotional stimulus in parental cancer: a study with adult children caregivers,” *European Journal of Cancer Care*, 23, 2013, p. 129, DOI: 19.1111/ecc.12102.

²³⁴ Alliance for Aging Research, “The Silver Book: Cancer,” http://www.silverbook.org/wp-content/uploads/2015/06/Silver-Book_Cancer_Fact-Sheet.pdf, accessed November 30, 2017.

²³⁵ Zafara, S., Peppercorn, J., et al., “The Financial Toxicity of Cancer Treatment,” *Oncologist*, 18(4), 2013, pp. 381-90 in Alliance for Aging Research, “The Silver Book: Cancer,” http://www.silverbook.org/wp-content/uploads/2015/06/Silver-Book_Cancer_Fact-Sheet.pdf, accessed November 30, 2017.

²³⁶ U.S. Department of Health and Human Services, Centers for Disease Control and Prevention and the National Cancer Institute, “Surveillance, Epidemiology, and End Results Program,” <https://seer.cancer.gov/faststats/selections.php?#Output>, accessed January 24, 2018. The 45.4% is based on adding columns by age: 9,380 cases for those under 20 and 872,251 cases for those 65 and older subtracted from the total of new cases in 2014 of 1,620,646. The number of new cases for those ages 20-64 was 739,015, or 45.4% of the total.

workers got cancer at the same rate as the general population, there would be an estimated 956 expected cancer cases among working BMWED members currently. But the standardized mortality ratio study done for this research, shows an SMR of 1.79 for BMWED members, meaning the expected number of those who will have cancer is instead 1,711, suggesting 755 excess cases among BMWED members. If the average total cost of cancer, according to OSHA is \$272,210, then the excess cost of cancer – above the cost of cancer that would be expected -- is \$226.1 million. And this does not account for a number of other social and economic burdens, some direct and some indirect. Using the NCI estimate of \$376,220 per case, the cost to the estimated BMWED community from cancer alone would be much higher, at \$304.6 million.²³⁷

So, how much does cancer cost the average MOW rail worker stricken by cancer? Approximately \$25,400 out-of-pocket over the course of their disease, with some paying substantially more. There are lost wages for the rail worker, and often for a family member. There are lower employer retirement contributions made, resulting in lower retirement payments.

Data show that half of all men have cancer at some point in their lives, and lifetime out-of-pocket expenses alone are \$25,400 on average; so, just among active working BMWED members, 17,500 are likely to have cancer during their lives, with combined out-of-pocket expenses over the course of their disease of \$436 million. If the average cancer patient survives more than five years, then out-of-pocket expenditures would expand to well over \$127,000 per person. For the 755 BMWED excess cases currently living, those out-of-pocket expenses are expected to be approximately \$19.2 million – but to be conservative, we estimate the cost at half that, or \$9.6 million.

Added to the above costs are lost income for family members who are caretaking; cash payments to caretakers; lost future Social Security and retirement income for family caretakers; out-of-pocket co-pays, drugs, travel to doctors and parking; lost future income to children who forego education in order to care for a sick relative or who forego income by postponing entrance into the work force.

The total estimated cost of cancer associated with each affected BMWED member is \$300,000 to \$404,000. The excess cancers due to work exposure, of current BMWED members with cancer, cost the BMWED community \$226 million to \$305 million. (See Table 7.)

²³⁷ These costs are societal and have not been allocated to individual parties or groups of parties because of the complexities of third-party payment and differences across treatments and geography. This is especially the case of allocation of burden among employers, private insurers, workers compensation, and Federal Employers Liability Act (FELA)-sanctioned legal compensation.

Table 7: Estimated Costs of Cancer to Individuals and to the BMWED Community*		
Cost Category	Average Cost to the Individual	Cost to the BMWED Community (in million \$s)
<u>Direct and Indirect Costs</u> (as estimated by OSHA and NCI)	\$272,210-\$376,220	\$205.5-\$284.0
<u>Presenteeism</u> (12 days a year, at \$27.93 per hour, assumed to be working on the job for 5 years with the disease, assuming 1,665 excess members with cancer)	\$13,405	\$10.1
<u>Unpaid Caretaker Wages</u> (at \$12.51/hour for 18 hours per week for 5 years [\$11,709], for 10% of the 755 excess deaths)	\$1,171	\$0.9
Out-of-Pocket Expenditures (at \$25,440 per caregiver and 10% of excess cases, or 75.5, for five years)	\$12,720	\$9.6
<i>TOTAL</i>	<i>\$299,506-\$403,516</i>	<i>\$226.1-\$304.6</i>

*These costs are spread across several groups: individuals and their families, employers, insurance companies, government entities, and society at large.

Sources: Calculations within this report.

B. TWO MAJOR MUSCULOSKELETAL DISORDERS (MSDS)

Track maintenance work is the rail sector most associated with manual handling accidents and musculoskeletal disorders.²³⁸ Most maintenance-of-way rail workers walk on uneven, unstable ballast as part of their jobs. Slips, twists, falls, sprains, and strains are likely under such conditions,²³⁹ and stress most joints in the body. Musculoskeletal disorders include: carpal tunnel syndrome, tendonitis, rotator cuff injuries, epicondylitis (elbow problems), trigger finger, muscle strains, knee and hip problems, and low back injuries. The impacts of MSDs can be life-long. Workers with upper-extremity MSDs were more likely to have moved their residence, lost their home, lost their car, and lost their health insurance than a non-injured control group. They were more likely to have difficulties with basic daily activities such as writing, gripping, household chores, opening jars, child care, carrying bags, bathing, and driving a car. Over 40 percent of workers, 28 months after their initial claim, were still having difficulty pushing a window open, pouring from a container, writing with a pen, lifting a child, mopping floors, and placing items on a high shelf. Recreational activities were seriously curtailed.²⁴⁰

Lifting, pushing, pulling, and twisting at work are major causes of musculoskeletal disorders. On the BMWED survey in this study, 74 percent said that their job “always” involved repeated pushing, pulling, lifting, and bending. Another 23 percent said it did “sometimes” for a total of 97

²³⁸ Riley, D., “Manual Handling in the Rail Sector in South Wales, Executive Summary,” Health & Safety Laboratory, HSL/2006/53, 2006, p. V.

²³⁹ Andres, R. O., Wade, C., *Work*, 41 (2012) 3367-3371. DOI: 10.3233/WOR-2012-0609-3367.

²⁴⁰ Dembe, A., p. 409.

percent of surveyed workers. MOW work has historically been associated with high force, poor body positioning, and bending.²⁴¹ Maintenance-of-way workers frequently talk of lifting up to 200 pounds in the course of their work – spike kegs, cement bags, rail ties, dead animals, etc. The amount of weight lifted far exceeds recommended guidelines. NIOSH, for example, recommends that a worker not lift anything over 35 pounds without some type of assistive lift device.²⁴² NIOSH also has a lifting equation, based on frequency, lifting height, distance from body, etc., with a maximum load of 51 pounds.²⁴³ Research in the Netherlands found that any loads heavier than 25 kg (55 pounds) always creates a risk for lower back pain and injury.²⁴⁴ One BMWED worker interviewed said he developed shooting pains in his shoulder probably due to carrying 100-lb. bags of cement and other heavy objects. Another explained that he was required to do a lot of very heavy lifting and to work with hand tools which caused injury to his back over the years. A third explained how his back and knee problems were caused by lifting heavy weights during his 25 years on the railroad. Yet another said that at first, he had a lumbar sprain, but since his job involved a lot of heavy lifting, his back got worse year after year.

In comments added (without specific prompt) on the on-line survey, many maintenance-of-way workers discussed their problems with MSDs. Below are just a few of those comments.

- ❖ “I feel as though many of my joints are “worn out” from all my years on the track.”
- ❖ “All tools I have to pull or push -- claw bar, lining bar, sledge hammer -- cause pain to neck and throwing switches monthly. Back cannot do repetitive bending or set in chairs or vehicle seats that allow butt to be lower than knees. Back caused permanent nerve damage, drooped foot and shin numbness, accumulative damage from over flexing low back, Frog welding chair bent for hours. But was not reported as injury.”
- ❖ “Constant kneeling on railroad tracks using a grinder was the biggest and only reason my low back, knees, and shoulders bother me.”
- ❖ “My body is very tired, and I ache. I know as I age it will be difficult to keep up with the type of work I do. I know as I age and will at some point need to take time off to get my elbow/shoulder fixed. My knees also will need to be looked into further along with my feet and aching back. The steel shoe soles are creating another health problem!”
- ❖ “Body beat to hell from 42 years of track maintenance. Very few days that my body feels halfway good! Bouncing around in section truck(s) bench seat - back pain bad! Carrying jacks and using them on a daily basis - back pain and elbows! The use of "claw bar" very hard on your joints, neck and back! The use of sledge hammer(s) [and] spike maul(s), sent

²⁴¹ Gallagher, NIOSH, “Reducing Musculoskeletal Injuries in Rail Operations,” Bulletin (USDOL/MSHA), January-February 2008, pp. 17-22, <http://www.msha.gov/programs/hsapubs/2008/January-February2008.pdf>, accessed 2016.

²⁴² Wilder, S., “OSHA’s 35-lb. lifting limit,” *Long-Term Living*, December 9, 2013, <http://www.ltlmagazine.com/blogs/pamela-tabar/oshas-35-lb-lifting0limit?page=2>, accessed September 20, 2016.

²⁴³ Galassi, T., Director, Directorate of Enforcement Programs, Occupational Safety and Health Administration, “OSHA on lifting limits: Standard Interpretations,” May 4, 2015, https://www.osha.gov/pls/oshaweb/owadispl.show_document?p_table=INTERPRETATIONS&p_id=29936, accessed September 19, 2016.

²⁴⁴ Kuijer, P. et al., “An Evidence-Based Multidisciplinary Practice Guideline to Reduce the Workload due to Lifting for Preventing Work-Related Low Back Pain,” *Ann Occup Environ Med*, 26: 16., 2014, doi: [10.1186/2052-4374-26-16](https://doi.org/10.1186/2052-4374-26-16), <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4081511>, accessed November 9, 2016.

jolts through your hands, arms, neck, and back. You really felt it in your elbows! Carrying heavy tools, bars, gas tools, ties, x-ing planks back in the early days and while on sections is very hard and demanding!!”

- ❖ “Doctors ruled my degenerative arthritis was job-related due to using the vibrating tools such as rock drills, large impact tool, and all the vibrating tools pertaining to bridge work.”
- ❖ “Most of my hand problems are cramps and lack of grip strength which all came about after using a Monday maul (sledge hammer) to knock plates under the rail. I was on a tie gang where we were doing this for 12 plus hours a day, every day. I woke up numerous times in the night with my hands cramped up. Now I still have to do it here and there, and every time my hands feel like I have been doing it all day.”

And the list goes on.

Vibrating tools, forceful motions, and awkward or extreme postures while working are other important ergonomic hazards causing musculoskeletal disorders.²⁴⁵ Vibration is a significant cause of MSDs in MOW rail workers. Hand-arm vibration from tamping equipment puts many maintenance-of-way workers at risk of peripheral neurological disorders and also vascular disturbance, making early detection especially important.²⁴⁶ Whole body vibration increases the duration and intensity of musculoskeletal and/or neurological disorders of the spine, as well as other organ damage.²⁴⁷ In the survey that was part of this study, 56 percent of respondents said that vibration from vehicles and equipment at work bothered them always, often or sometimes. Fifty-nine percent said that hand tool vibration at work bothered them always, often or sometimes.

The American Academy of Orthopedic Surgeons estimated the total cost of musculoskeletal disorders in 1995 to be \$215.5 billion, or \$343.4 billion in 2016 dollars.²⁴⁸ In 1999, the Institute of Medicine and the National Research Council estimated that lost productivity due to musculoskeletal disorders was \$45 to \$54 billion, or \$65 billion to \$78 billion in 2016 dollars.²⁴⁹ These estimates are conservative compared to those of a White Paper by the Work Foundation’s Center for Workforce Health and Performance²⁵⁰ which estimated that direct medical costs related to MSDs from 2004 to 2006 were \$576 billion, or 4.5 percent of GDP and indirect costs (lost wages) due to MSDs were \$373 billion, or 2.9 percent of GDP. In 2016 dollars, the total of these direct and indirect costs would be \$686 billion and \$444 billion, respectively, for a total of over a trillion dollars in three years.

²⁴⁵ Hales, T.R., Bertsche, P.K., “Management of Upper Extremity Cumulative Trauma Disorders,” *AAOHN Journal*, Vol. 40, No. 3, March 1992, in U.S. Department of Health and Human Services, “Cumulative Trauma Disorders in the Workplace: Bibliography,” DHHS(NIOSH) Publication No. 95-119, p. 119.

²⁴⁶ Virokannas, H., “Dose-response relation between exposure to two types of hand-arm vibration and sensorineural perception of vibration,” *Occupational and Environmental Medicine*, 52, 1995, p. 332. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1128226/pdf/oenvmed00065-0044.pdf>, accessed February 15, 2017.

²⁴⁷ Johanning, Eckardt, “Whole-body vibration-related health disorders in occupational medicine – an international comparison, abstract,” *Ergonomics*, Vol 58, Issue 7, 2015, DOI: 10.1080/00140139.2015.1005170

NIOSH in a study of musculoskeletal disorders (MSDs) and the workplace²⁵¹ estimated conservatively, a cost of \$13 billion for MSDs in 1996 dollars, or \$20 billion in 2016 dollars.

Early intervention not only leads to better outcomes for the injured worker, but can save up to 72 percent or, on average, \$170,000 on each claim in 2013 dollars,²⁵² \$175,000 in 2016 dollars. Much of this saved cost is due to preventing lost work time. A study of MSDs related to the shoulder, for example, showed that 80 percent of the cost was due to lost work time and only 20 percent to direct medical costs.²⁵³ Furthermore, social support of family and friends reduces pain intensity, reliance on medicines, and encourages individuals to return to work.²⁵⁴

Both lower back pain and carpal tunnel syndrome are musculoskeletal diseases (MSDs) common among MOW workers and a focus of social and economic impact in this report. According to the Bone and Joint Initiative,²⁵⁵ in 2011, the median number of days away from work for all workplace injuries was 8 days; for MSD injuries, the median was 11 days. The full cost of MSDs to BMWED members is not calculated in this report -- only costs associated with lower back problems and carpal tunnel syndrome.

1. Lower Back Pain and Related Disability

“My back is shot” is the refrain of many railroad track workers. Back pain is the most prevalent and most costly work-related MSD.²⁵⁶ It is also a significant social problem in the U.S. and other industrialized nations because of the pain, suffering, and disability it causes.

a. Description and Progression of Lower Back Pain (LBP) and Disability. LBP often becomes a lifelong condition, with different stages of the disorder and different patterns of pain intensity or disability over time. There is clear evidence of an interaction between the person’s psychological state, employment, social setting, and recovery from lower back pain; it appears that back pain causes psychological and social problems, but also that psychological, employment, and

²⁵¹ Hales, T.R., Bertsche, P.K., “Management of Upper Extremity Cumulative Trauma Disorders,” *AAOHN Journal*, Vol. 40, No. 3, March 1992, in U.S. Department of Health and Human Services, *Cumulative Trauma Disorders in the Workplace: Bibliography*, DHHS(NIOSH) Publication No. 95-119, p. 119.

²⁵² Virokannas, H., p. 332.

²⁵³ Johanning, “Whole-body vibration-related health disorders ...”.

²⁵⁴ Prang, K. et al., “The Impact of Family and Work-Related Social Support on Musculoskeletal Injury Outcomes: A Systematic Review,” *J Occup Rehabil*, 25, DOI 10.1007/s10926-014-9523-8, 2015, p. 208, <https://www.ncbi.nlm.nih.gov/pubmed/24846079>, accessed February 2016.

²⁵⁵ Bone and Joint Initiative, *The Burden of Musculoskeletal Diseases in the United States: Prevalence, Societal and Economic Costs*, 3rd ed., chapter on injuries, 2016a, <http://www.boneandjointburden.org/2014-report/vi0/injuries>, accessed November 8, 2016.

²⁵⁶ U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, *Musculoskeletal Disorders and Workplace Factors: A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back*, July 1997, p. I-6.

social issues affect the prognosis for lower back pain.²⁵⁷ Chronic lower back pain creates both financial and emotional problems for the individual and his/her family, including conjugal problems, and unfortunately for the sufferer of lower back pain, it is not uncommon for it to co-occur with other MSDs like neck and shoulder pain.²⁵⁸ According to one survey respondent: “Back and leg pain all the time. Pain scale 7-8.”

Kovacs et al. found that the longer lower back pain lasts, the more likely the victim is to become disabled. They report that lower back pain:²⁵⁹

...influences disability and quality of life more than RP [referred pain]. Disability is predicted by pain duration and quality of life is predicted by disability, but pain severity predicts neither one of them. Changes related to determinants of disability and quality of life, and to the prediction of chronic disability, appear 14 days after the onset of pain, supporting that cutoff point for considering a patient as being subacute.

b. Causes of Lower Back Pain and Disability. Virtanen et al.²⁶⁰ looked at the connection between intervertebral disc disease (IDD), genetic factors, and occupational exposure to whole-body vibration. They found that whole-body vibration is likely to lead to IDD, as are certain genetic risk factors. In their study of blue and white-collar Malaysian rail workers, Ganasegeran et al.²⁶¹ found that 69 percent of the workers they interviewed had experienced lower back pain in the preceding month. Their interviews revealed that those who had been employed for more than 10 years, who lifted and lowered heavy loads, who stood a great deal, and who were under psychological stress were significantly more likely to experience lower back pain. They also found that the amount of pain workers experienced was greater among those “lifting and lowering heavy loads, working with vibrating vehicles and at a pace set by machines, working in a hot and humid environment, working in a cold environment and working in a prolonged standing posture.” One interviewee said that over the 21 years he worked for the railroad he injured his back and neck often -- he had four ruptured disks. Another said his back hurt all the time, and he has pain now in his hips and butt as well. Yet another said he injured his back many years ago when he was using a Mark III tamper which was designed without springs, so it gave his back a real pounding. He had surgery three times on his back. A fourth interviewee said he injured his

²⁵⁷ Miedema, H.S., “Prognosis and management of nonspecific musculoskeletal disorders,” PhD thesis, Erasmus University Medical Center, Rotterdam, 2016, pp. 15-16.

²⁵⁸ Mathew, J., Singh, S., Garis, S., Diwan, A., “Backing up the stories: The psychological and social costs of chronic low-back pain,” *International Journal of Spine Surgery*, 7, 2013, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4300970/pdf/IJSS-7-2013-02-001.pdf>, accessed 2016.

²⁵⁹ Kovacs, F.M., Abaira, V., Zamora, J., Fernández, C., “The transition from acute to subacute and chronic low back pain: a study based on determinants of quality of life and prediction of chronic disability,” *Spine*, 30(15), August 2, 2005, p. 1786.

²⁶⁰ Virtanen, I.M. et al, “Occupational and Genetic Risk Factors Associated with Intervertebral Disc Disease,” *Spine* 32(10), 2007, pp. 1129–1134.

²⁶¹ Ganasegeran, K., Perianayagam, W., Nagaraj, P., Al-Dubai, S.A.R., “Psycho-behavioral risks of low back pain in railway workers,” *Occupational Medicine*, 64, 2014, doi:10.1093/occmed/kqu039, pp. 372–375.

back doing so much heavy lifting. Often, he had to spend an hour or two in one position and could hardly straighten up when done. He gets stiff.

Van Dieën²⁶² seems to resolve some of the questions about the relationship between work tasks and lower back pain with a study he and colleagues did using new methods to measure mechanical loads on backs. The study found that:²⁶³

A significant exposure-response relationship was found for cumulative low-back torques and low-back pain, with a 2.4 to 5.1 times higher risk of low-back pain in the most exposed as compared with the least exposed participants. The result was strongly determined by the group that experienced the highest back loads, which mainly consisted of road workers. The latter may indicate that the exposure-response relationship is not linear, with increased risk only for people that are exposed to loads at the high end of the spectrum.

Lifting and lowering materials, frequent bending and twisting and vibration of the whole body are all work-related factors that lead to lower back pain.

c. Economic and Social Impact of Lower Back Pain and Disability. Lower back pain is one of the most pervasive work-related problem for maintenance-of-way workers. It is associated with major medical costs and significant absenteeism and presenteeism. Back pain often leads to significant disability and an inability to perform basic daily living functions.

Economic Costs of Lower Back Pain and Disability. Thousands of maintenance-of-way workers suffer from lower back pain. The suffering is often severe, but so are the economics. According to PhD research, by Chandwani, in 2013, excess direct medical costs per person for chronic back pain was over \$18,500 in 2011 dollars (or \$19,739 in 2016 dollars), for ambulatory visits, inpatient admissions, emergency department visits, and prescription medications. Chandwani concludes that the high cost of chronic back pain might motivate a change in policy to improve care and outcomes.²⁶⁴

Indirect costs for lower back pain include economic costs like legal fees, transportation, specialized chairs and mattresses, home modifications, and physical aids. According to the Bone and Joint Initiative,²⁶⁵ people with neck and back pain report that they spend an average of 12.3 days per year in bed as a result of the pain, more than the time reported for any other musculoskeletal condition. This strongly suggests that maintenance-of-way workers may miss days of work and

²⁶² Van Dieën, J., “Low-back pain, a consequence of cumulative mechanical loading?” May 23, 2014, <http://www.bodyinmind.org/low-back-pain-and-mechanical-loading/>, accessed November 9, 2016.

²⁶³ Ibid.

²⁶⁴ Chandwani, H.S., “The economic burden of chronic back pain in the United States: a societal perspective,” Ph.D. dissertation, University of Texas at Austin, 2013, p. vi, abstract at <https://repositories.lib.utexas.edu/handle/2152/23087>, accessed February 2016.

²⁶⁵ Bone and Joint Initiative, *The Burden of Musculoskeletal Diseases in the United States: Prevalence, Societal and Economic Costs*, 3rd ed., chapter on injuries, 2016a, <http://www.boneandjointburden.org/2014-report/vi0/injuries>, accessed November 8, 2016.

may need to hire help to care for them and do chores they can no longer do as a result of lower back pain caused by their working conditions. The railroad will either have to pay for replacement workers, or work short and further endanger the health and safety of other employees.

Neck and back pain account for one-third of the 216 million days lost from work in 2012 according to the Bone and Joint Initiative, with an average of seven days lost per year.²⁶⁶ A study on the burden of musculoskeletal diseases in the U.S., by the Bone and Joint Initiative, found that from 2009 to 2011, the average earnings loss due to MSDs was \$2,063, or \$2,201 in 2016 dollars.²⁶⁷

OSHA in its Safety Pays Estimator²⁶⁸ estimates both the direct and indirect costs of a range of back injury types; e.g., fracture, sprain, and strain, finding the direct costs range from \$29,989 per injury to \$50,778 and the indirect costs from \$32,987 to \$55,855, for a total per case of \$62,976 to \$196,633. The amount of additional sales needed to pay for each lower back case would be between from \$315,000 and \$533,000.

Social Costs of Lower Back Pain (LBP) and Disability. There are also significant social non-monetary impacts associated with back pain. In one study by Harvard researchers, fully two-thirds of those with LBP admitted to problems in relationships with their partners – one-third saying they were a lot worse and another third saying there were a little worse.²⁶⁹ Fifty percent said their sex lives changed for the worse. Nearly 50 percent of those with children said their relationships with their children were worse since the onset of their low-back pain. There was also significant guilt about not being able to care for older parents or having to ask them for money because of the impact of their pain. Fifty percent said that their social lives were much worse, and another 40 percent said they were a little worse; i.e., 90 percent reported that their social lives were affected negatively.²⁷⁰ One interviewee for this study spoke for many, saying it is now very hard for him to do chores around the house and yard and he is very limited because of his back.

d. *Costs of Lower Back Pain to the BMWED Membership and to Individuals.* One rail study already cited in this report²⁷¹ found 69 percent of rail workers experienced lower back

²⁶⁶ Bone and Joint Initiative, *The Burden of Musculoskeletal Diseases in the United States: Prevalence, Societal and Economic Costs*, 3rd ed., chapter on injuries, 2016a, <http://www.boneandjointburden.org/2014-report/vi0/injuries>, accessed November 8, 2016.

²⁶⁷ Bone and Joint Initiative, *The Burden of Musculoskeletal Diseases in the United States: Prevalence, Societal and Economic Costs*, 3rd ed., chapter on economic cost, 2016 p.42, <http://www.boneandjointburden.org/2014-report/vi0/injuries>, accessed November 8, 2016.

²⁶⁸ U.S. Department of Labor, Occupational Safety and Health Administration, “OSHA’s Safety Pays Program...”.

²⁶⁹ Mathew, J., Singh, S., Garis, S., Diwan, A., “Backing up the stories: The psychological and social costs of chronic low-back pain,” *International Journal of Spine Surgery*, 7, 2013, p. e36, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4300970/pdf/IJSS-7-2013-02-001.pdf>, accessed 2016.

²⁷⁰ Ibid.

²⁷¹ Ganasegeran, K., Perianayagam, W., Nagaraj, P., Al-Dubai, S.A.R., “Psycho-behavioural risks of low back pain in railway workers,” *Occupational Medicine*, 64, 2014, doi:10.1093/occmed/kqu039, pp. 372–375.

pain at least once a month. A study of U.S. railroad locomotive engineers²⁷² found that 75 percent experienced lower back pain more than one day a week, mostly from vibration. It is highly probable that the percentage would be higher among maintenance-of-way workers because of the more intense vibration their tools produce. The on-line survey of thousands of maintenance-of-way workers, done as part of this study, found that back pain was a common condition, either lower back pain more than 3 times/year (reported by 70.6%), lower back pain lasting more than 1 week at a time (43.4%), back pain during the past week (50.4%), or always (every day) or often (4-6 days/week) low back pain during the past week (27.0%). Only in a small percent of cases (7.1%) had there been “severe injuries or fractures in the area of current discomfort.” Therefore, most cases of low back pain were probably chronic conditions due to day-to-day physical work demands. In an even smaller percent of cases (5.3%) did members or retirees report having back problems when they started their present job. Therefore, railroad work probably contributed to many of the cases of back pain.²⁷³

Half of all working Americans report having back pain symptoms each year.²⁷⁴ At any given time, 31 million people experience lower back pain – or 12.4 percent of the adult population of 249 million people.²⁷⁵ It is estimated that lower back pain is 2.4 times to 5.1 times more prevalent in those who do frequent lifting and lowering, bending, twisting, and experience vibration²⁷⁶ – certainly all characteristic of maintenance-of-way work. The data suggest that the 12.4 percent of people in the general public who have lower back pain balloons to at least 29.8 percent to 63.4 percent of maintenance-of-way workers. And this is probably a conservative estimate because the intensity of the lifting and lowering, bending, twisting, and vibration characteristic of maintenance-of-way work. Not counting retirees (who, if injured, will probably seek medical treatment for their backs for their entire lives) if 29.8 to 63.4 percent of MOW workers have lower back pain, then 10,430 to 22,190 of all maintenance-of-way workers suffer from back pain. To be conservative, if only half of maintenance-of-way workers seek medical treatment for their back problems and/or miss work as a result of injury, then the relevant numbers would be 5,215 to 11,095 workers for whom costs need to be calculated. The on-line survey shows many workers who literally lost years of work due to back problems, and a very large number of others who lost months of work, not to count the costs of presenteeism.

²⁷² Johanning, E., Landsbergis, P., Fischer, S., Luhrman, R., “Back disorder and ergonomic survey among North American railroad engineers,” *J Transport Res Board*, 1899, 2004, pp. 145–155, <http://trrjournalonline.trb.org/doi/abs/10.3141/1899-19?journalCode=trr>, accessed November 13, 2016.

²⁷³ Landsbergis, P., Johanning, E., Stillo, M., Davis, M., “DRAFT: BMWED Health and Safety Survey: Summary of analyses of questions on working conditions, musculoskeletal disorders and cardiovascular disease,” January 17, 2018.

²⁷⁴ Vallfors B. *Acute, Subacute and Chronic Low Back Pain: Clinical Symptoms, Absenteeism and Working Environment*. *Scan J Rehab Med Suppl*, 1985; 11: 1-98 in American Chiropractic Association, “Back Pain Facts and Statistics,” <https://www.acatoday.org/Patients/Health-Wellness-Information/Back-Pain-Facts-and-Statistics>, accessed November 8, 2016.

²⁷⁵ American Chiropractic Association, “Back Pain Facts and Statistics,” <https://www.acatoday.org/Patients/Health-Wellness-Information/Back-Pain-Facts-and-Statistics>, accessed November 8, 2016.

²⁷⁶ Van Dieën, J.

The calculations for this paper are even more conservative. Retirees, who suffer many back problems are not counted. The assumption is that maintenance-of-way workers have at least as many back problems as railroad engineers; i.e. 75 percent of them, or 26,250. If the general population has a 50 percent rate of back problems, then maintenance-of-way workers have 25 percent more, or 8,750 excess cases of back issues.²⁷⁷ If only half seek medical treatment, then the excess number of rail workers for calculation purposes would be 4,375. If the average cost per injury or illness is \$130,000 per person, then excess costs to the BMWED community from members with current back issues are \$568.8 million. Again, this is a conservative estimate because over the sequence of a career, a maintenance-of-way worker could have more than one back problem.

While OSHA²⁷⁸ does not specifically estimate a cost for lower back problems, it does do per incident cost estimates for fractures, sprains, and strains – at \$63,000 to \$197,000, or an average of \$130,000. This estimate is probably low for back problems because back problems are the number one reason people miss work,²⁷⁹ thus costing employers in lost productivity and workers in lost wages. It is assumed here that there is an average of 12 days a year of presenteeism, probably extremely low given the level of pain and disability that so many maintenance-of-way workers report living with daily.

At an estimated average of \$130,000 per case, if there are currently 4,375 excess cases of lower back pain, the cost of back problems to the BMWED community is estimated to be \$568.8 million, for those current cases. The sales needed in the railroad industry to cover these costs at 20 percent to 30 percent profit margin, are from \$315,000 to \$533,000 per case, with needed “make-up” sales to pay for all excess back cases at \$1.1 billion to \$5.9 billion.

Better ergonomics could not only save an enormous amount of pain and suffering, but save rail workers, insurance companies, and railroad companies hundreds of millions of dollars. Not included here are additional costs due to pain, which can run into the tens of thousands of dollars per person. Nor is there a way to monetize damage to relationships with children, family and community, or sex life problems found among 2/3 of those with back problems. These figures also do not include the pain and suffering of the victim and the victim’s family.

Estimated average total cost per “excess case” with back problems is \$164,000 to \$204,000, with a total for the BMWED community of \$717 million to \$1.1 billion. (See Table 8.)

²⁷⁷ $35,000 \times 0.5 = 17,500$ expected from general pop. rate; $35,000 \times 0.75$ in rail population = 26,250. Excess= 8,750.

²⁷⁸ U.S. Department of Labor, Occupational Safety and Health Administration, “OSHA’s Safety Pays Program,” <https://www.osha.gov/dcsp/smallbusiness/safetypays/estimator.html>, accessed March 16, 2017.

²⁷⁹ Chandwani, abstract, p. v.

Table 8: Estimated Costs of Lower Back Problems to Individuals and to the BMWED Community*		
Cost Category	Average Cost to the Individual	Cost to the BMWED Community (in million \$s)
<u>Direct and Indirect Costs</u> (as estimated by OSHA)	\$130,000	\$568.8
<u>Presenteeism**</u> (12 days a year, assumed to be working on the job for 5-20 years with the affliction)	\$13,405-\$53,620	\$58.6-\$234.4
<u>Unpaid Caretaker Wages</u> (at \$12.51/hour for 18 hours per week for 5 years, for 10% of \$11,709 for the 4,375 excess cases [\$1,171 x 4,375])	\$1,171	\$5.4
<u>Out-of-Pocket Caretaker Expenditures</u> (at \$6,402 per caregiver and 10% of excess cases, (4,375), for 5 years)	\$3,201	\$14.0
<u>Out-of-Pocket Expenditures by the Worker</u> for 5-20 years (1/2 ave. caretaker amount = \$3,201 x 5 years)	\$16,005-\$64,020	\$70.0-\$280.0
TOTAL	\$163,782-\$203,997	\$716.5-\$1,102.6

*These costs are spread across several groups: individuals and their families, employers, insurance companies, government entities, and society at large.

** Most with back problems develop them early in their careers and may well live with the pain for 20 years or more. Only 5% of survey respondents had suffered back pain when beginning their work for the railroad.

Sources: Calculations within this report.

2. Carpal Tunnel Syndrome

Another major musculoskeletal disorder frequently found among maintenance-of-way workers is carpal tunnel syndrome (CTS). The Centers for Disease Control and Prevention (CDC)²⁸⁰ describes carpal tunnel as a “cumulative trauma disorder” which is caused by stress to the hand and wrist, often by repetitive motions, vibration, compression of the carpal tunnel, awkward hand positions, and forceful grasping or pinching. These are all activities common for maintenance-of-way workers. The result of such repetitive activities can lead to inflammation, resulting in compression of the median nerve as it passes through the wrist.^{281, 282} The compression causes pain, burning and tingling in the hand and fingers, nerve damage and muscle deterioration in the hand.²⁸³ CTS also causes numbness, dry palm, and the deterioration of the muscles at the base of the thumb.²⁸⁴

²⁸⁰ U.S. Department of Health and Human Services, Centers for Disease Control and Prevention (CDC), “Current Trends Occupational Disease Surveillance: Carpal Tunnel Syndrome,” *MMWR Weekly*, 38(28), July 21, 1989, pp. 485-489, <http://www.cdc.gov/mmwr/preview/mmwrhtml/00001423.htm>, accessed November 30, 2016.

²⁸¹ Rothstein, M.A., “Applications of behavioral genetics: outpacing the science?” *Nature Reviews: Genetics*, Vol. 6, doi:10.1038/nrg1687, pp. 793-798.

²⁸² U.S. Department of Health and Human Services, National Institute of Neurological Disorders and Stroke (NINDS), “Carpal Tunnel Syndrome Fact Sheet,” July 2012, http://www.ninds.nih.gov/disorders/carpal_tunnel/detail_carpal_tunnel.htm#3049_7, accessed November 30, 2016.

²⁸³ Ibid.

²⁸⁴ Canadian Centre for Occupational Health and Safety, “Work-related Musculoskeletal Disorders (WMSDs),” 2014, <http://www.ccohs.ca/oshanswers/diseases/rmirsi.html>, accessed February 1, 2016.

a. Description and Progression of Carpal Tunnel Syndrome. If not treated, carpal tunnel can lead to slowing of nerve impulses, loss of feeling, loss of strength, reduced coordination, and permanent muscle damage and inability to use the affected hand effectively. The Canadian Centre for Occupational Health and Safety²⁸⁵ describes the stages that work-related musculoskeletal diseases (including carpal tunnel syndrome) go through. In the early stages of the disease, individuals experience aching and tiredness of the affected limb during the work shift, but these symptoms disappear at night and during days off work. There is no reduction of work performance. In the intermediate stage, aching and tiredness occur early in the work shift and persist at night and the individual has a reduced capacity for repetitive work. In late stages of the disease, aching, fatigue, and weakness persist at rest and there is an inability to sleep and perform light duties.

The first pain is a signal that the muscles and tendons should rest and recover. Otherwise, an injury can become longstanding, and sometimes irreversible. The earlier people recognize symptoms, the more quickly they are able to rest, treat the problem, keep it from getting worse, and speed recovery.²⁸⁶

b. Causes of Carpal Tunnel Syndrome. Use of tools that vibrate, especially when the work also puts force on the wrist,²⁸⁷ very common for maintenance-of-way workers, are causes of CTS. One maintenance-of-way worker interviewed for this study said that he had had rotator cuff surgery three times and carpal tunnel surgery three times. Others also reported multiple surgeries on both the same joint and on a number of different joints. One survey respondent said, “I have severe hand pain and am losing strength on my hands.” Supporting the reports of the MOW workers we interviewed, Cartwright et al.²⁸⁸ found that, among manual laborers, those who had carpal tunnel were very likely to also have rotator cuff syndrome, which can also be caused by repetitive strain.

Bernard²⁸⁹ summarizes the research on causes of carpal tunnel syndrome as providing evidence of a relationship between carpal tunnel syndrome and highly repetitive work, either alone or in combination with other factors. There is also clear evidence of a relationship between forceful

²⁸⁵ Ibid.

²⁸⁶ WebMD, “How Do You Treat Carpal Tunnel Syndrome,” <https://www.webmd.com/pain-management/carpal-tunnel/treat-carpal-tunnel-syndrome#2>, accessed 2017.

²⁸⁷ Ohnari K., Uozumi T., Tsuji S., “Occupation and carpal tunnel syndrome, abstract,” *Brain Nerve*, 59(11), 2007, pp.1247-52, <http://www.ncbi.nlm.nih.gov/pubmed/18044201>, accessed February 9, 2016.

²⁸⁸ Cartwright, M.S. et al., “Examining the association between musculoskeletal injuries and carpal tunnel syndrome in manual laborers,” *Muscle Nerve*, 54(1): 2016 June, pp.31-5, doi: 10.1002/mus.24982, <https://www.ncbi.nlm.nih.gov/pubmed/26579702>, accessed February 2016.

²⁸⁹ Bernard, B.P., ed., *Musculoskeletal Disorders and Workplace Factors A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back, Chapter 5a, Carpal Tunnel Syndrome*, NIOSH Publication No. 97-141, 1997, <http://www.cdc.gov/niosh/docs/97-141/pdfs/97-141.pdf> accessed November 30, 2016.

work and carpal tunnel syndrome. The Washington State Department of Labor and Industries²⁹⁰ supports these conclusions, based on data from workers in that state. They find that “combinations of high force with high repetition and awkward posture; regular strong vibrations” result in a high risk of developing carpal tunnel syndrome.

One interviewee for this study explained that he has Carpal Tunnel Syndrome due to repetitive stress operating a 70-foot long tamper machine to surface the track. The tamper had 2 levers on the console that he moved back and forth all day long, resulting in thousands of repetitions. Another interviewee described his carpal tunnel as caused by the PB8 jackhammer he used for 7 or 8 years which caused distress from his elbows to his fingers.

c. Economic and Social Impacts of Carpal Tunnel Syndrome. If one does not treat early stages of carpal tunnel syndrome, the individual can lose their ability to use their hands to do their job and perform basic tasks of daily living like buttoning a shirt or holding a spoon. This has profound consequences for the individual and his/her family and also for the employer and for government programs.

Economic Costs of Carpal Tunnel Syndrome. Some of the most complete data available on economic direct costs of occupational injury were collected by the Washington State SHARP program.²⁹¹ This report’s data, from Washington State, were part of a large study of all workers’ claims in the state filed in 1993-1994 and followed-up for six years. The report reveals that workers with carpal tunnel syndrome missed more days from work (median: 138) than those with fractures (median: 46). In addition, “The typical CTS claimant loses about 30 percent more of their pre-injury level of earnings than do claimants with either dermatitis (DERM) or upper extremity fractures (FRAC).” The study also found that older workers lose more time from CTS and lose more income in subsequent years. Men working in construction or transportation lose more time and lose more long-term earnings when they develop CTS than do men working in “fixed-site industries.”

Indirect costs for carpal tunnel syndrome include familial, societal, and economic effects of injury and disease. They lose wages, family members may be negatively affected psychologically, and the patient and family may be less involved in their community involvement. These indirect losses can be just as powerful and painful as direct economic losses.

Even non-life-threatening conditions often carry large price tags. Using OSHA’s, in its Safety Pays Estimator,²⁹² yields direct costs of \$30,509 and indirect costs of \$33,559 for carpal tunnel syndrome, for a total cost per case of \$64,068. The amount of sales needed to pay for each case, based on a profit margin of 20 percent to 30 percent, is \$214,000 to \$320,000. With 1,505 more

²⁹⁰ Washington State Department of Labor and Industries, “Work-Related Carpal Tunnel Syndrome Diagnosis and Treatment Guideline,” 2009, 2014, <http://www.lni.wa.gov/ClaimsIns/Files/OMD/MedTreat/CarpalTunnel.pdf>, accessed 2016.

²⁹¹ Washington State Department of Labor and Industries SHARP (Safety & Health Assessment & Research for Prevention), “Economic Burden of Carpal Tunnel Syndrome,” circa 1994, <http://www.lni.wa.gov/safety/research/occhealth/reports/ctsburden/default.asp>, accessed February 9, 2016.

²⁹² U.S. Department of Labor, Occupational Safety and Health Administration, “OSHA’s Safety Pays Program,” <https://www.osha.gov/dcsp/smallbusiness/safetypays/estimator.html>, accessed March 16, 2017.

cases of carpal tunnel syndrome than would be expected from the rate of carpal tunnel in the U.S. male population aged 18-64 (“excess” cases), the total burden of excess carpal tunnel among active BMWED members is \$321 million to \$482 million.

Social Costs of Carpal Tunnel Syndrome. There are some clear losses to workers and their families of a member who has carpal tunnel syndrome. Many workers with CTS find that they are unable to perform family and social roles. Many develop depression, live with constant pain, and find that they are able to contribute less to community life.²⁹³ Over 40 percent of CTS claimants reported that other members of their household had to spend more time on household chores because of the patient’s disability. And they reported that their partners increased work hours due to their injuries, and they were more likely to be separated or divorced than those with fracture claims. Nearly 60 percent said they had to draw down their savings as a result of their carpal tunnel.²⁹⁴ CTS can mean that an individual is no longer able to tie shoes or button shirts, pick up small items, and sometimes not hold an eating utensil, requiring constant help from those around them. Interviews with BMWED workers and retirees showed this level of disability among many of them.

d. Costs of Carpal Tunnel Syndrome to the BMWED Membership and to Individuals. The direct cost of treating carpal tunnel syndrome depends on the type of treatment; e.g., outpatient vs. in-patient. While the procedure itself can cost, as discussed above, just \$1,700 to \$3,300, the average total direct plus indirect cost is actually much higher at \$64,068 per individual, according to OSHA. Much of the indirect cost is due to the high number of lost work days following a procedure. Many maintenance-of-way workers need surgery on both wrists, sometimes multiple times. The railroads need to make sales of \$214,000 to over \$320,000 in order to be able to pay the \$64,068 cost of carpal tunnel syndrome for one individual.

According to the National Health Interview Study, conducted by the U.S. Census, 3.6 percent of the employed male population have been told by a medical professional that they have carpal tunnel syndrome. Among respondents to the BMWED survey, from a similar demographic, the percentage is more than twice as high; 7.9 percent have been told that they have carpal tunnel syndrome. At 3.6 percent of 35,000 active members, one would expect 1,260 cases. If 7.9 percent of maintenance-of-way workers actually have carpal tunnel, that suggests that there would be 2,765 current cases of carpal tunnel among the 35,000 active BMWED members. The chances that carpal tunnel developed on the job are high. But if only the “excess” cases are counted, there are still 1,505 “excess” cases among the active membership of 35,000. The estimated total cost per individual, for the time period for which the case exists, is \$85,000 to \$150,000. If one only counts “excess cases,” the cost to the BMWED community would be \$128 million to \$226 million, and this does not include caretaking costs and the social costs associated with dependency as the syndrome becomes more serious. Using OSHA estimates and only the 1,505 excess cases, then total direct and indirect cost is \$96.4 million. If one uses the higher estimate of 2,765 cases,

²⁹³ Foley, M, Silverstein, B, Polissar, N., “The Economic Burden of Carpal Tunnel Syndrome: Long-Term Earnings of CTS Claimants in Washington State,” *American Journal of Industrial Medicine*, 50, 2007, p. 155, <https://www.ncbi.nlm.nih.gov/pubmed/17216630>, accessed February 2016.

²⁹⁴ Foley, M., Silverstein, B., “The Long-Term, Burden of Work-Related Carpal Tunnel Syndrome Relative to Upper-Extremity Fractures and Dermatitis in Washington State, *American Journal of Industrial Medicine*, 58, 2015, p. 1261, <https://www.ncbi.nlm.nih.gov/pubmed/26523842>, accessed February 2016.

acknowledging that nearly all of the cases are probably work-induced, then the total for direct and indirect cost is \$177.1 million. When adding in presenteeism and out-of-pocket costs, the total rises to \$128.6 million to \$225.3 million for the entire BMWED community. Even this high-level estimate does not include the significant costs to retirees and non-BMWED-represented MOW workers. (See Table 9.)

Table 9: Estimated Costs of Carpal Tunnel Syndrome to Individuals and to the BMWED Community*		
Cost Category	Average Cost to the Individual	Cost to the BMWED Community (in million \$s)
<u>Direct and Indirect Costs</u> (as estimated by OSHA)	\$64,068	\$96.4
<u>Presenteeism</u> ** (12 days a year, assumed to be working on the job for 5-20 years with the disease)	\$13,405-\$53,620	\$20.2-\$80.7
Out-of-Pocket	\$8,002-\$32,010	\$12.0-\$48.2
<i>TOTAL</i>	<i>\$85,475-\$149,630</i>	<i>\$128.6-\$225.3</i>

*These costs are spread across several groups: individuals and their families, employers, insurance companies, government entities, and society at large.

**Most with carpal tunnel develop it early in their careers and may well live with the pain, on-the-job for 20 years or more. To be conservative, the assumption is that the pain of carpal tunnel does not usually require a caretaker and that out-of-pocket expenses are half that of the other diseases.

Sources: Calculations within this report.

C. COSTS ASSOCIATED WITH FIVE OCCUPATIONAL HEALTH ISSUES

Conservative estimates of the cost of injury, illness, and death among maintenance-of-way workers still lead to very large numbers. For just five health issues, the costs for the BMWED community are \$1.7 billion - \$2.3 billion, as seen in Tables 10 and 11 below, Table 10 presents costs for an individual case, and Table 11 for the entire community of active BMWED members:

Table 10: Estimated Costs of Excess Individual Cases of 5 Major Health Issues Affecting Maintenance-of-Way Workers *					
Health Issue	COPD	Chronic Kidney Disease	Cancer	Back Problems	Carpal Tunnel Syndrome
Direct & Indirect Costs as Estimated by OSHA	\$103,118	\$103,118	\$272,210-\$376,220	\$130,000	\$64,068
Presenteeism	\$13,405	\$13,405	\$13,400	\$13,405-\$53,620	\$13,405-\$53,620
Out-of-Pocket Expenditures	\$16,005	\$16,005	\$12,720	\$16,005-\$64,020	\$8,002-\$32,010
Value of Unpaid Caretaker Wages	\$1,171	\$1,171	\$1,171	\$1,171	--
Caretaker out-of-Pocket Expenditures	\$3,201	\$3,201	--	\$3,201	--
<i>TOTAL</i>	<i>\$136,900</i>	<i>\$136,900</i>	<i>\$299,501-\$403,511</i>	<i>\$163,782-\$252,012</i>	<i>\$85,475-\$149,698</i>

*These costs are spread across several groups: individuals and their families, employers, insurance companies, government entities, and society at large.

Sources: Calculations within this report.

Table 11: Estimated Costs to the BMWED Community for 5 Major Health Issues Affecting Maintenance-of-Way Workers (In millions of 2016 dollars)*						
Health Issue	COPD	Chronic Kidney Disease	Cancer	Back Problems	Carpal Tunnel Syndrome	Total
Direct & Indirect Costs as Estimated by OSHA	\$134.9	\$335.6	\$205.5-\$284.0	\$568.8	\$96.4	\$1,341.2-1,419.7
Presenteeism	\$17.5	\$43.6	\$10.1	\$58.6-\$234.4	\$20.2-\$80.7	\$150.0-\$386.3
Out-of-Pocket Expenditures	\$20.9	\$52.1	\$9.6	\$70.0-\$280.0	\$12.0-\$48.2	\$164.6-\$410.8
Value of Unpaid Caretaker Wages	\$1.5	\$3.8	\$0.9	\$5.4	--	\$11.6
Caretaker out-of-Pocket Expenditures	\$4.2	\$10.4	--	\$14.0	--	\$28.6
TOTAL	\$179.0	\$445.5	\$226.1-\$304.6	\$716.8-\$1,102.6	\$128.6-\$225.3	\$1,696.0-\$2,257.0

*These costs are spread across several groups: individuals and their families, employers, insurance companies, government entities, and society at large.

Sources: Calculations within this report.

When costs to individuals are multiplied by the “excess deaths” above those expected, the costs for these five health problems alone come to \$1.7 billion to \$2.3 billion. Although this includes direct and indirect costs, it does not include the many personal, familial, community and societal costs we have discussed. Interventions to prevent even a percent of these illnesses and infirmities is in everyone’s interest.

Some might apply the economic concept of the “statistical value of life” to economic burden. This paper in no way suggests that there is a monetary value to human life. Nevertheless, the concept gives one an idea of the magnitude of the costs faced by the BMWED community. Economist Kip Viscusi introduced the concept for trade-off calculations in risk analysis. His 2000 estimate of \$7 million per statistical life²⁹⁵ is \$9.71 million in 2016 dollars. If one applied this only to cases of disease reported by current BMWED members, and multiplied \$9.71 million by the 5,318 “excess” lives lost by maintenance-of-way workers to COPD from diseases they currently have (1,308), chronic kidney disease (3,255), and cancer (775) to find that these diseases yield a lost value of nearly \$52 billion. The estimated value of a statistical life established within the U.S. government in 2016 was \$9.6 million.²⁹⁶ Using this estimate these 5,318 “excess” lives lost yield a lost value of \$51.1 billion.

²⁹⁵ Viscusi, W.K. and Aldy, J., The Value of a Statistical Life: A Critical Review of the Market Estimates Throughout the World, *Journal of Risk and Uncertainty*, 27:5-76), 2003, cited in U.S Department of Labor, Occupational Safety and Health Administration, “Preliminary Economic Analysis and Initial Regulatory Flexibility Analysis: Supporting Document for the Notice of Proposed Rulemaking for Occupational Exposure to Crystalline Silica,” 2013.

²⁹⁶ U.S. Department of Transportation, “Guidance on Treatment of the Economic Value of a Statistical Life...,” August 8, 2016,

D. OTHER HEALTH ISSUES FACING MAINTENANCE-OF-WAY WORKERS

Maintenance-of-way workers face a myriad of other health issues, all with severe economic consequences. This report selected just five to highlight. Because of lifting, twisting, vibration, and walking on ballast, it is not only one's back and wrists that are at risk, but also the feet, ankles, knees, hips, shoulders, and neck. The survey done of BMWED members also found a large number of members with other health problems. Many maintenance-of-way workers suffer from asbestos-related diseases and lead poisoning, as many older railroad bridges and trestles were built with friable asbestos and lead-based paint.²⁹⁷ Hearing loss and hernias are also work-related hazards for rail workers. There is high risk of being hit by a train or other moving vehicle on the tracks or of being hit by heavy equipment, tools, or flying debris.

There are many hazards associated with ballast. Ballast creates an unstable walking surface and can be especially hazardous when workers dismount from a train car or track maintenance vehicle. The ballast "shoulder" of the track bed is steeply sloped by engineering design, challenging balance particularly for MOW workers who must regularly navigate the ballast shoulder in the normal discharge of their work. According to the FRA, in 2011, over 15 percent of all railroad injuries were related to walking, slipping, stumbling, and falling as a result of debris (objects on the walking surface such as ballast or spikes).²⁹⁸ In addition, walking on ballast dramatically increases the biomechanical stresses on the lower extremities.²⁹⁹ Repeated dismounting from rail-mounted equipment onto ballast puts further stress on articular cartilage. An engineering study found that "walking on ballast affects the neuromuscular responses, apparently to stiffen the lower extremity joints, which in turn may affect the postural control mechanisms in a manner that increases the risk of slips, trips, and falls."³⁰⁰ And exposure to ballast dust can lead to silicosis as well as COPD.

Maintenance-of-way workers face many risks from hazardous chemical exposure, especially to their lungs. The three hazardous chemicals most often transported across the U.S. by rail and truck are ammonia, chlorine, and hydrogen fluoride. The first two can cause lung damage. Other risks from the three include blindness, headaches, nausea, vomiting, nose bleeds, chest pain, tooth damage, liver and kidney damage, and death.³⁰¹ Many railroad workers are exposed to these and

<https://www.transportation.gov/sites/dot.gov/files/docs/2016%20Revised%20Value%20of%20a%20Statistical%20Life%20Guidance.pdf>, accessed July 2, 2018.

²⁹⁷ Rincon Consultants, Inc., "Monterey Bay Sanctuary Scenic Train Network Master Plan, Final Environmental Impact Report, Prepared for Santa Cruz County Regional Transportation Commission, California," Section 4.8 Hazards and Hazardous Materials, Certified November 7, 2013, p. 4.8-9, <https://sccrtc.org/wp-content/uploads/2013/05/MBSST-Network-Master-Plan-FEIR.pdf>, accessed December 2016.

²⁹⁸ Andres, R.O., Wade, C., "Review of walking hazards for railroad workers," *Work*, 41, DOI: 10.3233/WOR-2012-0609-3367, 2012, p. 3368.

²⁹⁹ U.S. Department of Transportation, Federal Railroad Administration, Office of Railroad Policy & Development, "Joint Loading and Muscle Activity in the Lower Body While Walking on Ballast," R 11-04, March 2011.

³⁰⁰ Andres, R.O., Wade, C., p. 3371.

³⁰¹ PBS, "Top Hazardous Chemicals," <http://www.pbs.org/now/sgiws/226/hazardous-chemicals.html>, accessed November 9, 2015.

other known lung carcinogens -- silica, nickel-chromium, and polycyclic aromatic hydrocarbons.³⁰² Asbestos exposure is another risk to the lungs of railroad workers. Besides more common exposures, one 2014 study found the mechanical compression stress on ballast during passage of trains released asbestos and was implicated in the mesothelioma suffered by a track maintenance worker.³⁰³ Exposure to manganese, especially among MOW track welders, is suspected of causing neurological diseases.

Exposure to diesel exhaust fumes are also a significant health problem for MOW rail workers. Not only are they a probable human carcinogen, but they also cause eye, throat and bronchial problems, coughs, phlegm, and neurophysiological problems.³⁰⁴ A link has also been found between diesel exhaust and bladder cancer.³⁰⁵ Another connection has been found between diesel exhaust exposure and lung cancer in railroad workers.³⁰⁶

Chronic exposure to solvents can cause changes in cognition and behavior and this has been documented for railroad workers.³⁰⁷ Symptoms from solvent exposure include “headaches, dizziness, memory loss, mental dullness, distractibility, depression, anxiety, and irritability.”³⁰⁸ A study of railroad workers with long-term exposure to solvents (22 years on average) found solvent-induced toxic encephalopathy. One quarter also showed mental status abnormalities.³⁰⁹ Could these facts help explain why in a recent standardized mortality ratio study,³¹⁰ deaths from Alzheimer’s were more than seven times more prevalent among maintenance-of-way workers than in 18 to 64 year old men generally? Prevention averts suffering. It also saves many millions of dollars to workers and their families, railroad companies, insurers, and taxpayers.

³⁰² De Matteis, S. et al., “Impact of occupational carcinogens on lung cancer risk in a general population,” *Int. J. Epidemiol.*, doi: 10.1093/ije/dys042, March 2012.

³⁰³ Mastrangelo, G. et al., “A rare occupation causing mesothelioma: mechanisms and differential etiology,” abstract, <https://www.ncbi.nlm.nih.gov/pubmed/25134629>, accessed 2016.

³⁰⁴ Pronk, A., Coble, J., Steward, P., “Occupational exposure to diesel engine exhaust: A literature review,” *Journal of Exposure Science and Environmental Epidemiology*, 19, 2009, p. 443.

³⁰⁵ Boffetta, P., Silverman, D., “A Meta-Analysis of Bladder Cancer and Diesel Exhaust Exposure,” *Epidemiology*, Vol. 12, No. 1, January 2001, pp. 125, 129.

³⁰⁶ Dawson, S. et al., “Multi-State Model Estimates of Lung Cancer Risk from Exposure to Diesel Exhaust, Based on U.S. Railroad Worker Cohort,” *Risk Analysis*, Vol 21, No 1, 2001.

³⁰⁷ Haut, M.W. et al., “Corpus Callosum Volume in Railroad Workers with Chronic Exposure to Solvents,” *JOEM*, Volume 48, Number 6, June 2006, DOI:10.1097/01.jom0000205211.67120.23, p. 615.

³⁰⁸ Ibid.

³⁰⁹ Albers, J. et al., “Neurologic Evaluation of Workers Previously Diagnosed with Solvent-Induced Toxic Encephalopathy,” *Journal of Occupational and Environmental Medicine*, Vol 42(4), April 2000, p. 410.

³¹⁰ Goldsmith and Barlet.

IV. SUMMARY AND CONCLUSIONS

Maintenance-of-way workers on the railroad face many hazards and dangerous exposures. As a result, many more get sick or are injured than in the general population. Just five of the injuries and illnesses they face are documented in this study – chronic obstructive pulmonary disease (COPD), chronic kidney disease (CKD), cancer, lower back problems, and carpal tunnel syndrome. These are not the only hazards maintenance-of-way workers face, and they are not necessarily the most expensive. For these five, however, their social and economic impacts have been explored and costs calculated:

COPD. COPD is both permanent and progressive; there are no treatments to cure it, and it gradually worsens over time, though early diagnosis and treatment slows the rate of progression. COPD has a large social and economic impact on the lives of U.S. families and communities, limiting the resources families have to invest in themselves, the local economy, neighborhood institutions, and their communities. Maintenance-of-way rail workers are exposed daily to dust from ballast, which substantially increases their risk of developing COPD, which in turn leads to higher rates of COPD among maintenance-of-way workers, substantial economic costs and increased social and psychological stress on their families and communities. Not counting third-party payments or reductions in pension benefits for victim and caregiver, BMWED excess deaths only from COPD cost \$179 million. The cost per individual: close to \$140,000.

Chronic Non-Cancerous Kidney Disease. Chronic kidney disease and end-stage kidney disease are debilitating for the individuals with the disease, and for their families, their communities, and society. Large numbers of maintenance-of-way rail develop the disease due to exposure to ballast dust, herbicides, and other toxins. In fact, BMWED men, aged 18-64, are 2.5 times more likely to die of kidney disease than men of those ages generally.³¹¹ Because treatment of kidney disease often lasts over so many years, it is very costly to the patients' families as well as to insurers, Medicare, and support systems that help patients and their families. The conservative average lifetime cost per person for chronic kidney disease is estimated to be almost \$140,000. Total costs, therefore, for the 3,255 cases is close to \$450 million.

Cancer. Maintenance-of-way workers are regularly exposed to chemicals, dusts, and radiation associated with numerous types of cancer. Their exposure is much greater than in most other occupations. And maintenance-of-way workers are, indeed, found to have higher rates of cancer than the general population with a standardized mortality ratio of 1.79 overall, but as high as 2.17 for pancreatic cancer and 2.36 for liver cancer.³¹² Cancer costs the BMWED community half a billion dollars or more a year.

Lower Back Pain. Lower back pain is extremely widespread and costly to the individuals, railroad companies, the health care system, the insurance industry and to families and communities. Lower back pain causes more lost days from work than any other condition. It is a major cause of disability, putting strains on Medicare and Medicaid. It also causes an enormous amount of pain and suffering, often chronically, stressing families and communities as well as the individuals who

³¹¹ Ibid.

³¹² Goldsmith and Barlet.

suffer. Estimated average total cost per “excess case” with back problems is \$164,000 to \$204,000, with a total for the BMWED community of \$717 million to \$1.1 billion

Carpal Tunnel Syndrome. Carpal tunnel syndrome is a painful condition that affects at least 7.9 percent of those active members taking the BMWED survey. Early treatment can avoid surgery and/or permanent damage to the wrist. Vibration and repetitive motion are a major cause. Often those affected miss weeks of work to recover from surgery. More than 60 percent of carpal tunnel patients say they have to draw down on their savings because of their affliction. The estimated cost per individual, for the time period for which the worker has carpal tunnel disease, is \$85,000 to \$150,000. If one only counts “excess cases,” the cost to the BMWED community would be \$128 million to \$226 million.

Even with conservative assumptions, the economic costs of the “excess cases” of these health issues are \$1.7 billion to \$2.3 billion. Not included in these costs are lost income for family members who are caretaking; cash payments to caretakers; lost future Social Security and retirement income for family caretakers; out-of-pocket co-pays, drugs, travel to doctors and parking; lost future income to children who forego education in order to care for a sick relative or who forego income by postponing entrance into the work force, legal fees, specialized equipment, home modifications, and physical aids and a myriad of effects related to pain and suffering.

The government estimates that a life is worth \$9.6 million (statistical value of life). Adding up the excess lives lost to COPD, chronic kidney disease, and cancer by BMWED workers, we find 5,318 excess deaths. This means that, solely in economic terms, the value of lives lost is an alarming \$51 billion. Another way of looking at cost is to look at how many years of life are saved for each case of chronic disease prevented. So, if for each chronic disease prevented, one saves 14 life years, and if “excess deaths” from COPD, CKD, and cancer alone were saved, the BMWED community would have members living 74,452 more years of life. These are years that could be spent raising children, working productively and paying taxes, supporting communities, and loving spouses.

There is a broad range of potential policies and workplace changes that could simultaneously improve worker health and safety and also improve productivity and save money for workers, their families, their communities, railroad companies, and taxpayers. Healthy workers are more productive workers. So, any improvements are likely to be a win-win situation.

BIBLIOGRAPHY

- Aaronson, N. et al., “Beyond treatment – Psychosocial and behavioral issues in cancer survivorship research and practice,” *EJC Supplements*, 2014, <http://dx.doi.org/10.1016/j.ejcsup.2014.03.005>, accessed September 2016.
- AARP, “Valuing the Invaluable: The Economic Value of Family Caregiving, 2008 Update,” AARP Public Policy Institute, 2008, http://assets.aarp.org/rgcenter/il/i13_caregiving.pdf, accessed January 24, 2017.
- AARP, “Valuing the Invaluable: The Economic Value of Family Caregiving, 2008 Update,” AARP Public Policy Institute, 2008, http://assets.aarp.org/rgcenter/il/i13_caregiving.pdf, accessed January 24, 2017.
- AARP, “Valuing the Invaluable: The Economic Value of Family Caregiving, 2015 Update,” AARP Public Policy Institute, 2015, <http://www.aarp.org/content/dam/aarp/ppi/2015/valuing-the-invaluable-2015-update-new.pdf>, accessed January 24, 2017.
- Aetna Disability – Workability, “Supplemental Sickness Benefit Plan: Maintenance of Way Employees,” July 1, 2012.
- Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (2014). 2005-2011 Nationwide Inpatient Sample, 2012 State Inpatient Databases disparities analysis files, and AHRQ Quality Indicators, version 4.4. <http://www.ahrq.gov/research/findings/nhqrdr/2014chartbooks/womenhealth/wm-comm.html>, accessed October 19, 2016.
- Ahlstrom, B., Skarsater, I, Danielson, E., “Children’s View of a Major Depression Affecting a Parent in the Family,” *Issues in Mental Health Nursing*, DOI: 10.3109/1612840,2911,579689, 2011.
- Albers, J. et al., “Neurologic Evaluation of Workers Previously Diagnosed with Solvent-Induced Toxic Encephalopathy,” *Journal of Occupational and Environmental Medicine*, Vol 42(4), April 2000.
- Alliance for Aging Research, “The Silver Book: Cancer,” http://www.silverbook.org/wp-content/uploads/2015/06/Silver-Book_Cancer_Fact-Sheet.pdf, accessed November 30, 2017.
- Alzheimer’s Association, *2015 Alzheimer’s Disease: Facts and Figures*, 2015, http://www.alz.org/facts/downloads/facts_figures_2015.pdf, accessed May 21, 2017.

- Ambler, N., de C Williams, A.C., Hill, P., Gunary, R., Cratchley, G., “Sexual Difficulties of Chronic Pain Patients, abstract,” *The Clinical Journal of Pain*, June 2001, Volume 17, Issue 2., https://journals.lww.com/clinicalpain/Abstract/2001/06000/Sexual_Difficulties_of_Chronic_Pain_Patients.6.aspx, accessed April 15, 2018.
- American Cancer Society website, “What is Cancer?” <https://www.cancer.org/cancer/cancer-basics/what-is-cancer.html> accessed February 22, 2017.
- American Cancer Society, “Occupation and Cancer,” January 2015.
- American Chiropractic Association., “Back Pain Facts and Statistics,” n.d., <https://www.acatoday.org/Patients/Health-Wellness-Information/Back-Pain-Facts-and-Statistics>, accessed November 8, 2016.
- American College of Rheumatology, “Carpal Tunnel Syndrome,” <https://www.rheumatology.org/I-Am-A/Patient-Caregiver/Diseases-Conditions/Carpal-Tunnel-Syndrome>, accessed November 26, 2017.
- American Kidney Fund, “2015 Kidney Disease Statistics,” <http://www.kidneyfund.org/assets/pdf/kidney-disease-statistics.pdf>, accessed November 26, 2017.
- American Lung Association, n.d., “How Serious is COPD?” <http://www.lung.org/lung-health-and-diseases/lung-disease-lookup/copd/learn-about-copd/how-serious-is-copd.html>, accessed October 13, 2016.
- American Short Line and Regional Railroad Association, “The Short Line and Regional Railroad Industry,” https://www.aslrra.org/web/About/Industry_Facts/web/About/Industry_Facts.aspx?hkey=bd7c0cd1-4a93-4230-a0c2-c03fab0135e2, retrieved January 6, 2018.
- Andres, R. O., Wade, C., “Review of walking hazards for railroad workers,” *Work*, 41, DOI: 10.3233/WOR-2012-0609-3367, 2012.
- Armistead, L., Klein, K., Forehand, R., “Parental Physical Illness and Child Functioning,” *Clinical Psychology Review*, Vol 15, No 5, 1995.
- Armon, G. et al., “Joint Effect of Chronic Medical Illness and Burnout on Depressive Symptoms Among Employed Adults,” *Health Psychology*, Vol 33, No 3, 2014.
- Asfaw, A. Pana-Cryan, R., Bushnell, T. and Sauter, S., “Musculoskeletal Disorders and Associated Healthcare Costs Among Family Members of Injured Workers,” *American Journal of Industrial Medicine*, 58: 1205–1216, 2015, doi:10.1002/ajim.22500.
- Asfaw, A., Pana-Cryan R., and Rosa, R., “Paid Sick Leave and Nonfatal Occupational Injuries,” *American Journal of Public Health*, 102(9), September 2012, <http://www.ncbi.nlm.nih.gov/PM/articles/PMC3482022>, accessed September 2016.
- Association of America Railroads, “Class I Railroad Statistics,” <https://www.aar.org/Documents/Railroad-Statistics.pdf>, accessed May 3, 2016.

- Association of American Railroads, “Railroad Facts,” 2014 Edition, 2014.
- Axelsson, O. et al, “Herbicide exposure and tumor mortality: An updated epidemiologic investigation on Swedish railroad workers,” *Scand j work environ health*, 6, 1980.
- Bang, K.M., et al., “Chronic Obstructive Pulmonary Disease Prevalence Among Nonsmokers by Occupation in the United States,” *JOEM*, Vol 55, No 9, September 2013.
- Bank of England, “U.S. Dollar to Canadian Dollar Spot Exchange Rates for 2005 from the Bank of England,” <https://www.poundsterlinglive.com/bank-of-england-spot/historical-spot-exchange-rates/usd/USD-to-CAD-2005>, accessed October 19, 2017.
- Bentley, T. S., “2014 U.S. organ and tissue transplant cost estimates and discussion,” *Milliman Research Report*, December 2014, http://www.milliman.com/uploadedFiles/insight/Research/health-rr/1938HDP_20141230.pdf, accessed 2016.
- Bernard, B.P., ed., *Musculoskeletal Disorders and Workplace Factors A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back, Chapter 5a, Carpal Tunnel Syndrome*, NIOSH Publication No. 97-141, 1997, <http://www.cdc.gov/niosh/docs/97-141/pdfs/97-141.pdf>, accessed November 30, 2016.
- Bjorgvinsdottir, K., Hallodorsdottir, S., “Silent, invisible and unacknowledged: experiences of young caregivers of single parents diagnosed with multiple sclerosis,” *Scand J Caring Sci*, 2013.
- Boden, L., “How Often Do Workplace Injuries Go Unreported,” Harvard Catalyst Biostatistics Program Seminar, March 21, 2012, <https://catalyst.harvard.edu/docs/biostatsseminar/Boden-Catalyst0312fin.pdf>, accessed 2016.
- Boffetta, P., Silverman, D., “A Meta-Analysis of Bladder Cancer and Diesel Exhaust Exposure,” *Epidemiology*, Vol 12, No 1, January 2001.
- Bone and Joint Initiative (2016b) *The Burden of Musculoskeletal Diseases in the United States: Prevalence, Societal and Economic Costs* 3rd ed., chapter on economic costs. <http://www.boneandjointburden.org/2014-report/x0/economic-cost>, accessed November 15, 2016.
- Bone and Joint Initiative (2016c) *The Burden of Musculoskeletal Diseases in the United States: Prevalence, Societal and Economic Costs* 3rd ed., executive summary. <http://www.boneandjointburden.org/docs/BMUS%20Executive%20Summary%202016%20%282%29.pdf>, accessed November 15, 2016.
- Bone and Joint Initiative USA, “The Impact of Musculoskeletal Disorders on Americans – Opportunities for Action, Executive Summary,” 2014.

- Bone and Joint Initiative, *The Burden of Musculoskeletal Diseases in the United States: Prevalence, Societal and Economic Costs*, 3rd ed., chapter on injuries, 2016a, <http://www.boneandjointburden.org/2014-report/vi0/injuries>, accessed November 8, 2016.
- Bonk, M., ed., “Railroad Track Worker,” *Transportation*, 9th Edition, Macmillan Reference Detroit, 2007.
- Brotherhood of Maintenance-of-Way Employees, <http://www.bmwe.org/aboutus.shtm>, accessed November 1, 2015.
- Brotherhood of Maintenance-of-Way Employees, “Cowboy” Video: “A Brother’s Story, Dave ‘Cowboy’ Stevens,” accessed January 2017, <http://www.bmwe.org>.
- Brotherhood of Maintenance-of-Way Employees, IBT, “BMWED-IBT: History and Accomplishments,” <https://www.bmwe.org/secondary.aspx?id=22>, accessed October 27, 2016.
- Brotherhood of Maintenance-of-Way Employees, IBT, “Fatality Analysis of Maintenance of Way Employees and Signalmen (FAMES): 25 years of data shows 4th quarter spike in fatal roadway incidents,” December 3, 2015, <https://www.bmwe.org/secondary.aspx?id=104>, accessed October 27, 2016.
- Brotherhood of Maintenance of Way Employees Division, IBT, “Memo to All BMWED Division and System Officers from President Freddie N. Simpson,” on compensation package, March 10, 2017.
- Brown, J., “Occupational Renal Diseases,” n.d., <http://www.haz-map.com/renal.htm>, accessed December 16, 2016.
- Bushnell, P.T., Li, J., Landen, D., “Group Medical Claims as a Source of Information on Worker Health and Potentially Work-Related Diseases,” *JOEM*, Vol. 53, No. 12, December 2011, DOI: 10.1097/JOEM.0b013e3182363bbe, abstract at <https://www.ncbi.nlm.nih.gov/pubmed/22076036>, accessed February 2016.
- Cancer.Net, “Understanding the Costs Related to Cancer Care,” <http://www.cancer.net/navigating-cancer-care/financial-considerations/understanding-costs-related-cancer-care>, June 2015, accessed September 12, 2017.
- Canadian Centre for Occupational Health and Safety, “Work-related Musculoskeletal Disorders (WMSDs),” 2014, <http://www.ccohs.ca/oshanswers/diseases/rmirsi.html>, accessed February 1, 2016.
- Carey, T.S., et al, “The outcomes and costs of care for acute low back pain among patients seen by primary care practitioners, chiropractors, and orthopedic surgeons,” The North Carolina Back Pain Project, *N Engl J Med.*, 333(14):913-7, October 1995, <http://www.nejm.org/doi/pdf/10.1056/NEJM199510053331406>, accessed 2016.

- Carpal Tunnel HQ, “What is the Average Cost of Carpal Tunnel Surgery?” n.d., <http://carpaltunnelhq.com/what-is-the-average-cost-of-carpal-tunnel-surgery/>, accessed November 30, 2016.
- Cartwright, M.S. et al., “Examining the association between musculoskeletal injuries and carpal tunnel syndrome in manual laborers,” *Muscle Nerve*, 54(1): June 2016, pp. 31-5, doi: 10.1002/mus.24982, <https://www.ncbi.nlm.nih.gov/pubmed/26579702>, accessed February 2016.
- Catalan, J., et al., “Chromosomal Aberrations in Railroad Transit Workers: Effect of Genetic Polymorphisms,” *Environmental and Molecular Mutagenesis*, 50, 2009.
- Center for Food Safety, “World Health Organization Determines that Herbicide 2,4-D May Cause Cancer,” June 25, 2015, <http://www.commondreams.org/newswire/2015/06/25/world-health-organization-determines-major-herbicide-24-d-may-cause-cancer>, accessed February 14, 2017.
- Chandwani, H.S., “The economic burden of chronic back pain in the United States: a societal perspective,” Ph.D. dissertation, University of Texas at Austin, 2013, abstract at <https://repositories.lib.utexas.edu/handle/2152/23087>, accessed February 2016.
- Chen, R. et al., “Parental cancer diagnosis and child mortality – A population-based cohort study in Sweden,” *Cancer Epidemiology*, 39, 2015, p. 79, <http://dx.doi.org/10.1016/j.canep.2014.11.011>, accessed February 2016.,
- Chowdhury, T. et al., “Chronic kidney disease and life expectancy,” *Nephrology Dialysis Transplantation*, Volume 27, Issue 8, August 1, 2012, pp. 3182-3186, <https://academic.oup.com/ndt/article/27/8/3182/1816108>, accessed January 24, 2018
- Cigna, “Chronic Kidney Disease,” <http://www.cigna.com/healthwellness/hw/medical-topics/chronic-kidney-disease-aa65427>, accessed January 26, 2016.
- Coldstream, F., “A literature review of the potential effects of having a parent with chronic renal failure,” *Journal of Clinical Nursing*, DOI: 10.1111/j.1365-2702.2007.02154x, 2006.
- Commonwealth of Massachusetts, “Typical Costs for Common Medical Services,” April 2009.
- COPD Foundation, “Impact of COPD on Health Care Costs,” n.d., <https://www.copdfoundation.org/pdfs/Impact%20on%20Costs.pdf>, accessed October 18, 2016.
- COPD.com, “Learn COPD Basics,” n.d., <https://www.copd.com/about-copd>, accessed November 26, 2017.
- Costa, L., et al., “The prognosis of acute and persistent low-back pain: a meta-analysis,” *CMAJ*, 184(11): E613–E624, August 7, 2012, doi:10.1503/cmaj.111271. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3414626/>, accessed November 8, 2016.

- Dal Negro, R., "Optimizing economic outcomes in the management of COPD," *Int J Chron Obstruct Pulmon Dis*, 3(1), 2008, p. 2, <http://europepmc.org/articles/PMC2528207/>, accessed November 9, 2016.
- DaVita webpage, "What is Kidney Disease?" <https://www.davita.com/kidney-disease/overview>, accessed December 9, 2016.
- Dawson, S. et al., "Multi-State Model Estimates of Lung Cancer Risk from Exposure to Diesel Exhaust, Based on U.S. Railroad Worker Cohort," *Risk Analysis*, Vol 21, No 1, 2001.
- De Matteis, S. et al., "Impact of occupational carcinogens on lung cancer risk in a general population," *Int. J. Epidemiol.*, doi: 10.1093/ije/dys042, March 2012.
- De Matteis, S., Consonni, D., Bertazzi, P., "Exposure to occupational carcinogens and lung cancer risk. Evolution of epidemiological estimates of attributable fraction," *Acta Bio-Medica: Atenei Parmensis*, 79 Suppl 1, 2008, https://air.unimi.it/retrieve/handle/2434/54733/9262/ActaBiomed2008_79S1-34_Exposure-DeMatteis.pdf
- Dembe, A., "The social consequences of occupational injuries and illnesses," *American Journal of Industrial Medicine*, DOI: 10.1002/ajim.113, October 2001.
- Doney, B. et al., "Prevalence of Chronic Obstructive Pulmonary Disease Among US Working Adults Aged 40 to 70 Years," October 2014, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4555867/>, accessed January 24, 2018.
- Dong, X.S. et al., "Economic Consequences of Workplace Injuries in the United States," *American Journal of Industrial Medicine*, 59:106-118, doi 10.1002/ajim.2259, 2016.
- Eisner, M.D. et al., "Development of disability in chronic obstructive pulmonary disease: beyond lung function," *Thorax*, 2010, 66, pp. 108-114. <http://thorax.bmj.com/content/66/2/108.full.pdf>, accessed October 11, 2016.
- Eriksson, J.K., et al., "Healthcare costs in chronic kidney disease and renal replacement therapy: a population-based cohort study in Sweden," *BMJ*, 6:e012062. doi:10.1136/bmjopen-2016-012062, 2016, <http://bmjopen.bmj.com/content/bmjopen/6/10/e012062.full.pdf>, accessed December 9, 2016.
- Federal Interagency Workgroup, *Healthy People 2020*, n.d., <https://www.healthypeople.gov/2020/topics-objectives/topic/respiratory-diseases> accessed October 13, 2016.
- Foley, M. Silverstein, B., Polissar, N., "The Economic Burden of Carpal Tunnel Syndrome: Long-Term Earnings of CTS Claimants in Washington State," *American Journal of Industrial Medicine*, 50, 2007, <https://www.ncbi.nlm.nih.gov/pubmed/17216630>, accessed February 2016.

- Foley, M., Silverstein, B., “The Long-Term, Burden of Work-Related Carpal Tunnel Syndrome Relative to Upper-Extremity Fractures and Dermatitis in Washington State, *American Journal of Industrial Medicine*, 58, 2015, <https://www.ncbi.nlm.nih.gov/pubmed/26523842>, accessed February 2016.
- Ford, E.S. et al., “Total and State-Specific Medical and Absenteeism Costs of COPD Among Adults Aged ≥ 18 Years in the United States for 2010 and Projections Through 2020,” *Chest* 147(1), 2015, pp. 31 – 45, available at http://journal.publications.chestnet.org/data/Journals/CHEST/931880/chest_147_1_31.pdf, accessed 2016.
- Foster, G., “Children who live in communities affected by AIDS,” *The Lancet*, Vol 367, February 25, 2006.
- Freburger, J.K. et al, “The Rising Prevalence of Chronic Low Back Pain,” *Arch Intern Med.*, 169(3), 2009 Feb 9, doi: 10.1001/archinternmed.2008.543, pp. 251–258.
- Galassi, T., Director, Directorate of Enforcement Programs, Occupational Safety and Health Administration, “OSHA on lifting limits: Standard Interpretations,” May 4, 2015, https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=29936, accessed September 19, 2016.
- Gallagher, NIOSH, “Reducing Musculoskeletal Injuries in Rail Operations,” *Bulletin* (USDOL/MSHA), January-February 2008, available at <http://www.msha.gov/programs/hsapubs/2008/January-February2008.pdf>, accessed 2016.
- Ganasegeran, K., Perianayagam, W., Nagaraj, P., Al-Dubai, S.A.R., “Psycho-behavioural risks of low back pain in railway workers,” *Occupational Medicine*, 64, 2014, doi:10.1093/occmed/kqu039, pp. 372–375.
- Gaskin, D. J. and Richard, P., “The economic costs of pain in the United States.” Appendix C in Institute of Medicine, (US) Committee on Advancing Pain Research, Care and Education. *Relieving Pain in America: A Blueprint for Transforming Prevention, Care, Education, and Research*, Washington DC, National Academies Press, <https://www.ncbi.nlm.nih.gov/books/NBK92521/>, accessed November 15, 2016.
- Giacomini, M., DeJean, D., Simeonov, D., Smith, A., “Experiences of living and dying with COPD: a systematic review and synthesis of the qualitative empirical literature,” *Ont Health Technol Assess Ser [Internet]*, March 2012, 12(13):1-47, www.hqontario.ca/en/mas/tech/pdfs/2012/rev_COPD_Qualitative_March.pdf, accessed 2016.
- Goldsmith, D. and Barlet, G., “Follow-up Mortality Study of Certain Craft Railroad Workers, Ages 18-64,” publication pending, 2017.
- Grande, D., Barg, F., Johnson, S., Cannuscio, C., “Life Disruptions for Midlife and Older Adults with High Out-of-Pocket Health Expenditures,” *Annals of Family Medicine*, 2013.
- Guo, J. et al., “Testicular cancer, occupation and exposure to chemical agents among Finnish men in 1971-1995,” *Cancer Causes and Control*, 16, 2005.

- Hales, T.R., Bertsche, P.K., “Management of Upper Extremity Cumulative Trauma Disorders,” *AAOHN Journal*, Vol. 40, No. 3, March 1992, in U.S. Department of Health and Human Services, *Cumulative Trauma Disorders in the Workplace: Bibliography*, DHHS(NIOSH) Publication No. 95-119.
- Hamer, R.A., El Nahas, A.M., “The burden of chronic kidney disease: Is rising rapidly worldwide,” *BMJ: British Medical Journal*, 332(7541), 2006, pp. 563–564. doi:10.1136/bmj.332.7541.563, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1397782/pdf/bmj33200563.pdf>, accessed December 12, 2016.
- Haut, M.W. et al., “Corpus Callosum Volume in Railroad Workers with Chronic Exposure to Solvents,” *JOEM*, Vol 48, No 6, June 2006, DOI:10.1097/01.jom0000205211.67120.23.
- Haz-Map, “Occupational Cancer,” January 2015, <http://www.haz-map.com/cancer.htm>, accessed July 27, 2015.
- Healthcare Blue Book*, “Carpal Tunnel Surgery,” 2016, <https://healthcarebluebook.com/page/ProcedureDetails.aspx?id=119&dataset=MD>, accessed November 30, 2016.
- Hertel, D.W., *History of the Brotherhood of Maintenance of Way Employes: Its Birth and Growth, 1887-1955*, Ransdell Inc. Publishers, Washington, DC, 1955.
- Holt, S., Buckley, H., Whelan, S., “The impact of exposure to domestic violence on children and young people: A review of the literature,” *Child Abuse and Neglect*, 32, DOI: 10.1016/j.chiabu.2008.02.004, 2008.
- Howell, K. et al., “Children Facing Parental Cancer Versus Parental Death: The Buffering Effects of Positive Parenting and Emotional Expression,” *J Child Fam Stud*, April 2015, DOI 10.1007/s10826-015-0198-3.
- Hoy, D., March, L., Brooks, P., et al., “The global burden of low back pain: estimates from the Global Burden of Disease 2010 study,” *Ann Rheum Dis*, 2014; 73:968–974.
- Huber, M.B. et al., “Excess Costs of Comorbidities in Chronic Obstructive Pulmonary Disease: A Systematic Review,” *PLOS ONE*, 10(4), e0123292, DOI: 10.1371/journal.pone.0123292, <http://journals.plos.org/plosone/artoc?eod=10.1371/journal.pone.0123292>, accessed September 4, 2015.
- Institute of Medicine (US), Committee on Advancing Pain Research, Care and Education, “Relieving Pain in America: A Blueprint for Transforming Prevention, Care, Education, and Research,” Washington DC, National Academies Press, 2011, <https://www.ncbi.nlm.nih.gov/books/NBK92521/> accessed November 15, 2016.
- International Agency for Research on Cancer (IARC), “IARC Monographs evaluate DDT, lindane, and 2,4-D,” Press Release 236, June 23, 2015, https://www.iarc.fr/en/media-centre/pr/2015/pdfs/pr236_E.pdf, accessed October 2016.

- International Brotherhood of Teamsters, “Comments on Occupational Exposure to Respirable Crystalline Silica,” OSHA Rulemaking, Docket No. OSHA-2010-0034, February 11, 2014.
- Jayadevappa, R. et al., “The Burden of Out-of-Pocket and Indirect Costs of Prostate Cancer,” *The Prostate*, 70, 2010.
- Jayasumana, C. et al, “Drinking well water and occupational exposure to Herbicides is associated with chronic kidney disease, in Padavi-Sripure, Sri Lanka,” *Environmental Health*, 2015.
- Jeppesen, E. et al., “Does a parental history of cancer moderate the associations between impaired health status in parents and psychosocial problems in teenagers: a HUNT study,” *Cancer Medicine* 3(4), 2014, p. 919, DOI: 10.1002/cam4.245.
- Jinnett, K. et al., “Chronic Conditions, Workplace Safety, and Job Demands Contribute to Absenteeism and Job Performance,” *Health Affairs*, 36, No 2, doi: 10.1377/hlthaff.2016.1151, pp. 237-244.
- Johanning, E., Landsbergis, P., Fischer, S., Luhrman, R., “Back disorder and ergonomic survey among North American railroad engineers,” *J Transport Res Board*, 1899, 2004, pp. 145–155, <http://trrjournalonline.trb.org/doi/abs/10.3141/1899-19?journalCode=trr>, accessed November 13, 2016.
- Johanning, Eckardt, “Whole-body vibration-related health disorders in occupational medicine – an international comparison, abstract” *Ergonomics*, Vol 58, Issue 7, 2015, DOI: 10.1080/00140139.2015.1005170.
- Johnston, M., Martin, D., “Long-Term Parental Illness and Children: Perils and Promises,” *School Counselor*, Vol. 39, Issue 3, January 1992.
- Keating, N., Fast, J., Lero, D., Lucas, S., Eales, J., “A taxonomy of the economic costs of family care to adults,” *The Journal of the Economics of Aging*, 2014, <http://dxdoi.org/10.1016/j.jeoa.2014.03.002>, accessed February 2016.
- Kent, S., Schlackow, I., Lozano-Kühne, J., Reith, C., Emberson, J., Haynes, R., Gray, A., Cass, A., Baigent, C., Landray, M. J, Herrington, W., Mihaylova, B.; SHARP Collaborative Group, “What is the impact of chronic kidney disease stage and cardiovascular disease on the annual cost of hospital care in moderate-to-severe kidney disease?” *BMC Nephrol.* 2015 Apr 29;16:65, doi: 10.1186/s12882-015-0054-0, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4424521/pdf/12882_2015_Article_54.pdf, accessed 2017.
- Kernian, Leslie, n.d., <https://www.caring.com/questions/life-expectancy-of-copd> accessed October 20, 2016.
- Kochanek, K.D., Murphy, S. L., Xu, J., Tejada-Vera, B., *Deaths: Final Data for 2014*, National Vital Statistics Reports Volume 65, Number 4, June 30, 2016, https://www.cdc.gov/nchs/data/nvsr/nvsr65/nvsr65_04.pdf, accessed February 20, 2017.

- Kovacs, F.M., Abaira, V., Zamora, J., Fernández, C., “The transition from acute to subacute and chronic low back pain: a study based on determinants of quality of life and prediction of Chronic disability,” *Spine*, 30(15):1786-1792, August 1, 2005, <https://www.ncbi.nlm.nih.gov/pubmed/16094282>.
- Krattenmacher, T. et al., “A comparison of the emotional and behavioral problems of children of patients with cancer or a mental disorder and their association with parental quality of life,” *Journal of Psychosomatic Research*, Vol 76, Issue 3, March 2014, [http://www.jpsychores.com/article/S0022-3999\(13\)00436-4/fulltext](http://www.jpsychores.com/article/S0022-3999(13)00436-4/fulltext), accessed February 2016.
- Kuijer, P. et al., “An Evidence-Based Multidisciplinary Practice Guideline to Reduce the Workload due to Lifting for Preventing Work-Related Low Back Pain,” *Ann Occup Environ Med*, 26: 16., 2014, doi: [10.1186/2052-4374-26-16](https://doi.org/10.1186/2052-4374-26-16), <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4081511/>, accessed November 9, 2016.
- Landsbergis, P., Johanning, E., Stillo, M., Davis, M., “DRAFT: BMWED Health and Safety Survey: Summary of analyses of questions on working conditions, musculoskeletal disorders and cardiovascular disease,” January 17, 2018.
- Leader, D., “Can COPD Impact Your Employment? How to live and work with this chronic illness,” Very Well webpage, 2016, <https://www.verywell.com/copd-and-work-914950>, accessed October 11, 2016.
- LeBlanc, K.E., “Carpal Tunnel Syndrome,” *Am Fam Physician*, April 15, 2011, 83(8): 952-958, <http://www.aafp.org/afp/2011/0415/p952.html>, accessed December 6, 2017.
- Levine, D.I., Toffel, M.W., “Government Regulation That Actually Works,” *Harvard Business Review*, May 30, 2012.
- Levine, M., “Banned Wood Preservatives Still on Sale,” *LA Times*, December 21, 1986, http://articles.latimes.com/1986-12-21/local/me-4302_1_wood-preservatives, accessed December 15, 2016.
- Lewandowski, W., Morris, R., Draucker, C., Risco, J., “Chronic Pain and the Family: Theory-Driven Treatment Approaches,” *Issues in Mental Health Nursing*, DOI: 10.1080/01612840701522200, 2007.
- Lindberg, A., Bjerg-Backlund et al., “Prevalence and underdiagnosis of COPD by disease severity and the attributable fraction of smoking: Report from the Obstructive Lung Disease in Northern Sweden Studies,” *Respiratory Medicine*, Volume 100, Issue 2, February 2006, pp. 264-272, <https://www.sciencedirect.com/science/article/pii/S0954611105001952>, accessed January 25, 2018.
- Liu, Y. et al., “The association of chronic obstructive pulmonary disease, disability, engagement in social activities, and mortality among US adults aged 70 years or older, 1994–2006,” 2014:9 75–83.

- Mariotto, A.G., Yabroff, K.R. et al., “Projections of the Cost of Cancer Care in the United States: 2010-2010,” *Journal of the National Cancer Institute*, 103(2), January 2011, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3107566/>, accessed September 12, 2017.
- Mastrangelo, G. et al., “A rare occupation causing mesothelioma: mechanisms and differential etiology,” abstract, <https://www.ncbi.nlm.nih.gov/pubmed/25134629>, accessed 2016.
- Mastrangelo, G., Fadda, E., Marzia, V., “Polycyclic Aromatic Hydrocarbons and Cancer in Man,” *Environmental Health Perspectives*, Vol 104, No 11, November 1996.
- Mathew, J., Singh, S., Garis, S., Diwan, A., “Backing up the stories: The psychological and social costs of chronic low-back pain,” *International Journal of Spine Surgery*, 7, 2013, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4300970/pdf/IJSS-7-2013-02-001.pdf>, accessed 2016.
- Maverick, J.B., “What is the average profit margin for a company in the railroads Sector?, February 11, 2015, <http://www.investopedia.com/ask/answers/021115/what-average-profit-margin-comapny-railroads-sector.asp>, accessed September 14, 2017.
- Mayr, M., Roland, S., “Pancreatic cancer and depression: myth and truth,” *Cancer*, BioMed Central, 2010.
- Mendes, A., “COPD in the community: working beyond boundaries,” *British Journal of Community Nursing*, Vol 19, No 10, October 2014.
- Merrill, C.T., Nagamine, M., and Elixhauser, A., “Hospital Stays Involving Pulmonary Heart Disease,” 2005; “HCUP Statistical Brief #43,” December 2007. Agency for Healthcare Research and Quality, Rockville, MD. <http://www.hcup-us.ahrq.gov/reports/statbriefs/sb43.pdf>, accessed October 18, 2016.
- Miedema, H.S., “Prognosis and management of nonspecific musculoskeletal disorders,” PhD thesis Erasmus University Medical Center Rotterdam, 2016.
- Moore, B. et al., “Costs for Hospital Stays in the United States, 2012,” U.S. Department of Health and Human Services, Agency for Healthcare Research and Quality, Healthcare Cost and Utilization Project, October 2014.
- Morey, K. (chair Institute of Occupational Safety and Health’s Railway Group, UK), “Time to tackle occupational cancer,” November 25, 2015, <http://www.railpro.co.uk/railpro-magazine/december-2015-issue/time-to-tackle-occupational-cancers>, accessed July 3, 2016.
- Mossanen, M., Gore, J., “The burden of bladder cancer care: direct and indirect costs,” *Curr Opin Urol*, Vol 24, 2014 Sep; 24(5), pp. 487-91.
- Muehrer, R. et al., “Factors Affecting Employment at Initiation of Dialysis,” *Clin J Am Soc Nephrol*, 6(3), March 2011, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3082405>, accessed January 24, 2018.

- Muneer, S., "Socioeconomic Burden of Chronic Pain," *American Health and Drug Benefits*, October 2015, <http://www.ahdbonline.com/articles/2003-socioeconomic-burden-of-chronic-pain>, accessed February 9, 2016.
- Naik, A. et al., "The effects of age, education, and treatment on physical, sexual and body concern symptoms among multimorbid, colorectal cancer survivors," *Journal of Geriatric Oncology*, 6, 2015, <http://dx.doi.org/10.1016/j.jgo.2015.04.001>, accessed August 2016.
- Nair, K. et al., "Burden of Illness for an Employed Population with Chronic Obstructive Pulmonary Disease," *Population Health Management*, Vol 15, DOI: 10.1089/pop.2011.0049, November 5, 2012.
- National Cancer Institute webpage, "Staging," <https://www.cancer.gov/about-cancer/diagnosis-staging/staging> accessed February 22, 2017.
- National Cancer Institute webpage, "What is Cancer?" <https://www.cancer.gov/about-cancer/understanding/what-is-cancer>, accessed February 22, 2017.
- National Cancer Institute, "Statistics at a Glance: The Burden of Cancer in the United States," 2016, <https://www.cancer.gov/about-cancer/understanding/statistics>, accessed February 22, 2017.
- National Cancer Institute. 2014. "A snapshot of bladder cancer," <https://www.cancer.gov/research/progress/snapshots/bladder>, accessed February 22, 2017.
- National Foundation for Cancer Research, "Prevention Kits," http://www.nfcr.org/blog-and-news/prevention-kits/?gclid=EAIaIQobChMIrbm0x4il1gIVDoJpCh1btg-dEAAAYASAAEgKMtFD_BwE, accessed September 14, 2017.
- National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), "Kidney Disease Statistics for the United States," n.d., <https://www.niddk.nih.gov/health-information/health-statistics/Pages/kidney-disease-statistics-united-states.aspx#3>, accessed 2016.
- National Kidney Foundation, "About Chronic Kidney Disease: A to Z Health Guide," <https://www.kidney.org/atoz/content/about-chronic-kidney-disease>, accessed January 24, 2018.
- National Kidney Foundation website, n.d., "Dialysis," <https://www.kidney.org/atoz/content/dialysisinfo>, accessed February 14, 2017.
- National Kidney Foundation, "Prevention," n.d., <https://www.kidney.org/prevention>, accessed December 15, 2016.
- National Kidney Foundation, "Top 5 Jobs Kidneys do," n.d., <https://www.kidney.org/kidney-disease/top-5-jobs-kidneys-do>, accessed December 15, 2016.
- National Safety Council, *Injury Facts*, 2016.

- O'Sullivan, T., "Workplace Injuries Affect Families for Years," *Lifelines*, February 2016, Vol. 12, No. 9, <https://www.lhsfna.org/index.cfm/lifelines/february-2016/workplace-injuries-affect-families-for-years/>, accessed February 2016.
- Ohnari K., Uozumi T., Tsuji S., "Occupation and carpal tunnel syndrome, abstract," *Brain Nerve*, 59(11), 2007, pp.1247-52, <http://www.ncbi.nlm.nih.gov/pubmed/18044201>, accessed February 9, 2016.
- Patel, J.G., Nagar, S.P., Dalal, A.A., "Indirect costs in chronic obstructive pulmonary disease: A review of the economic burden on employers and individuals in the United States," *International Journal of COPD*, 9, 2014.
- Piette, J.D., Rosland, A.M., Silveira, M.J., Hayward, R., McHorney, C.A., "Medication cost problems among chronically ill adults in the US: did the financial crisis make a bad situation even worse?" *Patient Preference and Adherence*, Dovepress, DOI: 18.2147:PPA.517363.
- Police Officers Research Association of California, "Law Enforcement Presumptive On-Duty Injuries: Labor Code Section 3212, Presumptions for Heart, Hernia and Pneumonia," <http://porac.org/resources/law-enforcement-presumptive-on-duty-injuries/>, accessed September 20, 2016.
- Prang, K. et al., "The Impact of Family and Work-Related Social Support on Musculoskeletal Injury Outcomes: A Systematic Review," *J Occup Rehabil*, 25, DOI 10.1007/s10926-014-9523-8, 2015, <https://www.ncbi.nlm.nih.gov/pubmed/24846079>, accessed February 2016.
- Probst, T. and Estrada, A., "Accident under-reporting among employees: Testing the moderating influence of psychological safety climate and supervisor enforcement of safety practices," *Accident Analysis and Prevention*, 42, doi:10.1016/j.aap.2009.06.027, 2010,
- Progressive Railroading, "Vegetation management: Railroads are pulling out all the stops," *Progressive Railroading*, February 2008, <http://www.progressiverailroading.com/mow/article/Vegetation-management-Railroads-are-pulling-out-all-the-stops--15029>, accessed October 7, 2015.
- Pronk, A., Coble, J., Steward, P., "Occupational exposure to diesel engine exhaust: A literature review," *Journal of Exposure Science and Environmental Epidemiology*, 19, 2009.
- Railroad Retirement Board, "Q&A: Disability Annuities for Railroad Employees," October 2015, <https://www.rrb.gov/NewsRoom/NewsReleases/Q%26A%3A%20Disability%20Annuities%20for%20Railroad%20Employees>, accessed November 28, 2017.
- Renal Association, "CKD Stages," n.d., <http://www.renal.org/information-resources/the-uk-eckd-guide/ckd-stages#sthash.V9s3sl0G.dpbs>, accessed December 9, 2016.
- Ricci J.A., Stewart, W.F., Chee E., Leotta, C., Foley, K., Hochberg, M.C., "Back pain exacerbations and lost productive time costs in United States workers," *Spine*, 15;31(26), December 2006.

- Riley, D., “Manual Handling in the Rail Sector in South Wales, Executive Summary,” Health & Safety Laboratory, HSL/2006/53, 2006.
- Rincon Consultants, Inc., “Monterey Bay Sanctuary Scenic Train Network Master Plan, Final Environmental Impact Report, Prepared for Santa Cruz County Regional Transportation Commission, California,” Section 4.8 Hazards and Hazardous Materials, Certified November 7, 2013, p. 4.8-1., <https://sccrtc.org/wp-content/uploads/2013/05/MBSST-Network-Master-Plan-FEIR.pdf>, accessed December 2016.
- Robinson, T.A., “The Role of Presumptions Within the Workers’ Compensation Arena,” LexisNexis: Legal Newsroom, Workers Compensation Law,” January 21, 2014, <https://www.lexisnexis.com/legalnewsroom/workers-compensation/b/recent-cases-news-trends-developments/archive/2014/01/21/the-role-of-presumptions-within-the-workers-compensation-arena.aspx?Redirected=true#sthash.5ovSetgq.dpuf>, accessed September 20, 2016.
- Rothstein, M.A., “Applications of behavioral genetics: outpacing the science?” *Nature Reviews: Genetics*, October 2005, Vol 6, doi:10.1038/nrg1687.
- Rubinstein, S., Wang, C., Qu, W., “Occupational risk and chronic kidney disease: a population-based study in the United States adult population,” *International Journal of Nephrology and Renovascular Disease*, 6, 2013.
- Ruser, J., “Examining evidence on whether BLS undercounts workplace injuries and illnesses,” *Monthly Labor Review*, August 2008, <http://www.bls.gov/opub/mlr/2008/08/art2full.pdf>, retrieved 2008.
- Ruttenberg, R., “Testimony of Dr. Ruth Ruttenberg, President, Ruth Ruttenberg & Associates, on Behalf of the AFL-CIO Before Administrative Law Hearings on Proposed Silica Rule,” Occupational Safety and Health Administration, U.S. Department of Labor, January 2014.
- Ruttenberg, R., Cardi, J., Fenton, E. “The Taxpayer’s Burden from Product-Related Harm,” *Kansas Journal of Law and Public Policy*, Vol XXI, No. 1, Fall 2011.
- Sabath, E., Robles-Osorio, M.L. “Renal Health and the environment: heavy metal nephrotoxicity, abstract,” *Nefrologia*, 32(3), May 14, 2012.
- Said, S., Hernandez, G., “Environmental Exposures, Socioeconomics, Disparities, and the Kidneys,” *Advances in Chronic Kidney Disease*, Vol 22, No 1, January 2015.
- Schneider, K. M., O’Donnell, E.E., Dean, D., “Prevalence of multiple chronic conditions in the United States’ Medicare population.” *Health Qual Life Outcomes*. 2009; 7: 82. Published online 2009 Sep 8, doi: [10.1186/1477-7525-7-82](https://doi.org/10.1186/1477-7525-7-82), PMID: PMC2748070 <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2748070/>, accessed 2016.
- Schneider, K.M. et al., “Health Quality Life Outcomes,” September 8, 2009, in <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2748070/>, accessed February 14, 2017.

- Schulte, P.A., “Some implications of genetic biomarkers in occupational epidemiology and practice,” *Scandinavian Journal of Work, Environment & Health*, 30(1), 2004.
- Schulte, P.A., Lomax, G., “Assessment of the Scientific Basis for Genetic Testing of Railroad Workers with Carpal Tunnel Syndrome,” *JOEM*, Vol 45, No 6, June 2003.
- Shapiro, S., Ruttenberg, R., Leigh, P., “The Social Costs of Dangerous Products: An Empirical Investigation,” *Cornell Journal of Law and Public Policy*, Vol 18, No 3, Summer 2009.
- Sieh, D., Visser-Meily, J., Meijer, A., “Differential Outcomes of Adolescents with Chronically Ill and Health Parents,” *J Child Fam Stud*, DOI 10.1007/s10826-012-9570-8, 2013.
- Simpson, A.C. et al., “A day at a time: caregiving on the edge in advanced COPD,” *International Journal of COPD*, 2010:5 141–151.
- Snell, T., “Fragile families take toll on communities – Organizations looking for ways to work together to lend a hand,” *Tahlequah Daily Press*, May 20, 2014.
- Snider, J.T. et al., “The Disability Burden of COPD,” *COPD: Journal of Chronic Obstructive Pulmonary Disease*, 9(5), 2012, <http://dx.doi.org/10.3109/15412555.2012.696159>.
- Soderland, P. et al., “Chronic Kidney Disease Associated with Environmental Toxins and Exposures,” *Advances in Chronic Kidney Disease*, Vol 17, No 3, May 2010.
- Sponholtz, T.R., Sandler, D.P., Parks, C.G., Applebaum, K.M., “Occupational exposures and chronic kidney disease: Possible associations with endotoxin and ultrafine particles,” *Am J Ind Med*, 59(1), 2016, pp. 1-11. doi: 10.1002/ajim.22541, 2016, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4760/>, accessed December 12, 2016.
- State of California, “Law Enforcement Presumptive On-Duty Injuries: Labor Codes,” n.d. <http://porac.org/resources/law-enforcement-presumptive-on-duty-injuries>, accessed September 20, 2016.
- State of Minnesota, Department of Labor and Industry, Occupational Safety and Health Division, “Health Considerations for Workplace Exposure to Silica,” August 2012.
- Statista.com, “Leading North American railroads in 2016, based on operating revenue,” <https://www.statista.com/statistics/271613/leading-north-american-railroad-companies-based-on-revenue/>, accessed December 7, 2017.
- Stewart, W.F. et al., “Lost Productive Time and Cost Due to Common Pain Conditions in the US Workforce,” *JAMA*. 290(18), pp. 2443-2454, 2003, doi:10.1001/jama.290.18.2443.
- Stoeckel, M., Weissbrod, C., Ahrens, A., “The Adolescent Response to Parental Illness: The Influence of Dispositional Gratitude,” *J Child Fam Stud*, DOI 10.1007/s10826-014-9955-7, 2015.

- Stokes, J.B., "Consequences of Frequent Hemodialysis: Comparison to Conventional Hemodialysis and Transplantation," *Trans Am Clin Climatol Assoc*, 2011, Vol 122; 124-136, PMC3116337, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3116337>, accessed February 14, 2017.
- Stommel et al. in Fortner, B. et al., "Description and Predictors of Direct and Indirect Costs of Pain Reported by Cancer Patients," *Journal of Pain and Symptom Management*, Vol 25, No 1, January 2003.
- Strong, K., Mathers, C., Leeder, S., Beaglehole, R., "Preventing chronic diseases: how many lives can we save?" *Chronic Diseases 1. The Lancet*, DOI: 10.1016/50140-6736(05)67341-2, October 2005.
- Sullivan, S., "Employer Challenges with the Chronic Kidney Disease Population," *J Manag Care Pharm*, 13(9 suppl D), December 2007, S19-21.
- Sullivan, S.D., Ramsey, S.D., Lee, T.A., "The Economic Burden of COPD," *Chest*, 117 (2.Supplement): 5S-9S, 2000, http://dx.doi.org/10.1378/chest.117.2_suppl.5S.
- Summers, K. et al, "Musculoskeletal Disorders, Workforce Health and Productivity in the United States, Executive Summary," The Work Foundation, Center for Workforce Health and Performance, June 2015, http://www.theworkfoundation.com/wp-content/uploads/2016/11/385_White-paper-Musculoskeletal-disorders-workforce-health-and-productivity-in-the-USA-final.pdf, accessed February 2016.
- Tangka, F. et al., "State-Level Estimates of Cancer-Related Absenteeism Costs," *JOEM*, Vol 55, No 9, September 2013.
- Teixeira, R., Pereira, M., "Psychological morbidity and autonomic reactivity to emotional stimulus in parental cancer: a study with adult children caregivers," *European Journal of Cancer Care* 23, 2013, p. 129, DOI: 19.1111/ecc.12102.
- Theodore, B., Mayer, T., Gatchel, R., "Cost-Effectiveness of Early Versus Delayed Functional Restoration for Chronic Disabling Occupational Musculoskeletal Disorders," *J Occup Rehabil*, 25, 2015, DOI 10.1007/s10926-014-9539-0, <https://www.ncbi.nlm.nih.gov/pubmed/25194706>, accessed 2016.
- Tollefson, J., Usher, K., Foster, K., "Relationships in pain: The experience of relationships to people living with chronic pain in rural areas," *International Journal of Nursing Practice*, 2011, doi: 10.1111/j.1440-172X.2011.01963.x, <https://www.ncbi.nlm.nih.gov/pubmed/21939479>, accessed February 2016.
- Toy, E.L., K.F. Gallagher, Swensen, A.R., Duh, M.S., "The economic impact of exacerbations of chronic obstructive pulmonary disease and exacerbation definition: a review," *COPD*, 7(3), doi: 10.3109/15412555.2010.481697, June 2010.

- Trivedi, H., “Cost Implications of Caring for Chronic Kidney Disease: Are Interventions Cost-effective?” *Public Health Perspectives in Chronic Kidney Disease*, Advances in Chronic Kidney Disease, 17(3) 2010.
- Troudeau-Hern, S., Daneshpour, M., “Cancer’s Impact on Spousal Caregiver Health,” *Contemp Fam Ther*, DOI 10.1007/s10591-012-9211-9, October 2012.
- Tsai, T.Y., H. Livneh, M.D. Lu, P.Y. Tsai, P.C. Chen, F.C. Sung (2013). Increased risk and related factors of depression among patients with COPD: a population-based cohort study. *BMC Public Health* 13:976. doi: 10.1186/1471-2458-13-976.
- U.S. Census Bureau, “Population Estimates, July 1, 2016,” <https://www.census.gov/quickfacts/fact/table/US/PST045216#viewtop>, accessed November 26, 2017.
- U.S. Census Bureau, “Quick Facts, United States, Population Estimates, July 1, 2016,” <https://www.census.gov/quickfacts/fact/table/US/PST045216>, accessed November 26, 2017.
- U.S. Congressional Research Service, “Railroad Retirement Board: Retirement, Survivor, Disability, Unemployment, and Sickness Benefits,” Congressional Research Service, RS22350, September 1, 2014, http://greenbook.waysandmeans.house.gov/sites/greenbook.waysandmeans.house.gov/files/RS22350_gb_0.pdf, accessed March 16, 2017.
- U.S. Department of Health & Human Services, Centers for Disease Control and Prevention (CDC), “Chronic Obstructive Pulmonary Disease (COPD),” <https://www.cdc.gov/copd/index.html>, accessed October 20, 2016.
- U.S. Department of Health and Human Services, “Cumulative Trauma Disorders in the Workplace: Bibliography,” DHHS(NIOSH) Publication No. 95-119.
- U.S. Department of Health & Human Services, Centers for Disease Control and Prevention (CDC) webpage (n.d.), “Increase Expected in Medical Care Costs for COPD,” <http://www.cdc.gov/features/ds-copd-costs/>, accessed October 13, 2016.
- U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, “CDC National Health Report: Leading Causes of Morbidity and Mortality..., 2005-2013,” *MMWR*, October 31, 2014, <https://www.cdc.gov/mmwr/preview/mmwrhtml/su6304a2.htm>, accessed February 2017.
- U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, “Increase Expected in Medical Care Costs for COPD,” last updated July 2014, <http://www.cdc.gov/features/ds-copd-costs/> accessed October 13, 2016.
- U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Agency for Toxic Substances and Disease Registry (updated 2016). “Public Health Statement for Creosote. 1.9 What recommendations has the federal government made to protect human health?” <https://www.atsdr.cdc.gov/phs/phs.asp?id=64&tid=18#bookmark09>, accessed February 2017.

- U.S. Department of Health and Human Services, Centers for Disease Control and Prevention (CDC), “Chronic Kidney Disease (CKD) Surveillance Project: Frequently Asked Questions,” n.d., <https://nccd.cdc.gov/ckd/help.aspx?section=F#1>, accessed December 12, 2016.
- U.S. Department of Health and Human Services, Centers for Disease Control and Prevention (CDC), “Current Trends Occupational Disease Surveillance: Carpal Tunnel Syndrome,” *MMWR Weekly*, 38(28), July 21, 1989, pp. 485-489, <http://www.cdc.gov/mmwr/preview/mmwrhtml/00001423.htm>, accessed November 30, 2016.
- U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, “Occupational Injury: Do Family Members Pay a Price?” NIOSH Research Rounds, Vol 1, Issue 5, November 2015, <https://www.cdc.gov/niosh/research-rounds/resroundsv1n5.html>, accessed February 1, 2016.
- U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, “Financial Burden of Medical Care: A Family Perspective,” *NCHS Data Brief*, No. 142, January 2014, <http://www.cdc.gov/nchs/data/databriefs/db142.htm>, accessed November 8, 2015.
- U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Agency for Toxic Substances and Disease Registry, “Creosote Health Facts,” November 2006, [https://www.atsdr.cdc.gov/sites/KerrMcGee/docs/Creosote%20Health%20Effects%20\(Tronox\).pdf](https://www.atsdr.cdc.gov/sites/KerrMcGee/docs/Creosote%20Health%20Effects%20(Tronox).pdf), accessed January 1, 2017.
- U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, *Musculoskeletal Disorders and Workplace Factors: A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back*, July 1997.
- U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, “QuickStats: Percentage of Employed Adults Aged 18–64 Years Who Had Carpal Tunnel Syndrome in the Past 12 Months, by Sex and Age Group — National Health Interview Survey, 2010,” *Morbidity and Mortality Weekly Report (MMWR)*, December 16, 2011, <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6049a4.htm>, accessed November 30, 2016.
- U.S. Department of Health and Human Services, Centers for Disease Control and Prevention and the National Cancer Institute, “Surveillance, Epidemiology, and End Results Program,” <https://seer.cancer.gov/faststats/selections.php?#Output>, accessed January 24, 2018.
- U.S. Department of Health and Human Services, Federal Interagency Workgroup, “Healthy People 2020,” (n.d.), <https://www.healthypeople.gov/2020/topics-objectives/topic/respiratory-diseases>, accessed October 13, 2016.

- U.S. Department of Health and Human Services, National Institute of Neurological Disorders and Stroke (NINDS), “Carpal Tunnel Syndrome Fact Sheet,” July 2012, http://www.ninds.nih.gov/disorders/carpal_tunnel/detail_carpal_tunnel.htm#3049_7, accessed November 30, 2016.
- U.S. Department of Health and Human Services, National Institutes of Health, “Depression - for health professionals,” <http://www.cancer.gov/about-cancer/coping/feelings/depression-hp-pdq>, accessed May 27, 2015.
- U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute, “Cancer Prevalence and Cost of Care Projections: Annualized Mean Net Costs of Care,” <https://costprojections.cancer.gov/annual.costs.html>, accessed September 12, 2017.
- U.S. Department of Health and Human Services, National Institutes of Health, National Heart, Lung, and Blood Institute, *National Heart, Lung, and Blood Institute Education Strategy Development Workshop: Chronic Obstructive Pulmonary Disease*, 2005.
- U.S. Department of Health and Human Services, National Institutes of Health, National Heart, Lung and Blood Institute, “What is COPD?” 2014, <https://www.nhlbi.nih.gov/health/health-topics/topics/copd>, accessed February 20, 2017.
- U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion, “Respiratory Diseases,” *Healthy People 2000*, September 16, 2017, <https://www.healthypeople.gov/2020/topics-objectives/topic/respiratory-diseases>, accessed September 17, 2017.
- U.S. Department of Health and Human Services, Office of Women’s Health, *Men’s health: Chronic lower respiratory diseases*, January 2011, <https://www.womenshealth.gov/mens-health/top-health-concerns-for-men/chronic-lower-respiratory-diseases.html>, accessed February 20, 2017.
- U.S. Department of Labor, Bureau of Labor Statistics, “CPI Inflation Calculator,” https://www.bls.gov/data/inflation_calculator.htm, accessed October 19, 2017.
- U.S. Department of Labor, Bureau of Labor Statistics, “Industries at a Glance: Rail Transportation: NAICS 482,” <https://www.bls.gov/iag/tgs/iag482htm>, data extracted March 10, 2017.
- U.S. Department of Labor, Occupational Safety and Health Administration, “OSHA’s Safety Pays Program,” <https://www.osha.gov/dcsp/smallbusiness/safetypays/estimator.html>, accessed March 16, 2017.
- U.S. Department of Labor, Occupational Safety and Health Administration, “Adding Inequality to Injury: The Costs of Failing to Protect Workers on the Job,” June 2015, <https://www.dol.gov/osha/report/20150304-inequality.pdf>, accessed October 29, 2016.
- U.S. Department of Labor, Occupational Safety and Health Administration, “Silica, Crystalline,” n.d., <https://www.osha.gov/dsg/topics/silicacrystalline/index.html>, accessed November 23, 2017.

- U.S. Department of Transportation, “Guidance on Treatment of the Economic Value of a Statistical Life...,” August 8, 2016, <https://www.transportation.gov/sites/dot.gov/files/docs/2016%20Revised%20Value%20of%20a%20Statistical%20Life%20Guidance.pdf>, accessed July 2, 2018.
- U.S. Department of Transportation, Federal Railroad Administration, “Casualties (Deaths and Injuries) to Employees on Duty (By Calendar Year, Jan-Dec), Maintenance of Way and Structures Employees,” <http://safetydata.fra.dot.gov/officeofsafety/publicsite/Query/castally1.aspx>, accessed November 14, 2015.
- U.S. Department of Transportation, Federal Railroad Administration, Office of Railroad Policy & Development, “Joint Loading and Muscle Activity in the Lower Body While Walking on Ballast,” R 11-04, March 2011.
- U.S. Department of Transportation, National Highway Traffic Safety Administration, “The Impact of Motor Vehicle Crashes 2000,” 59 Table 22, 2002, available at <http://lhsc.lsu.edu/OutsideLinks/EconomicImpact-1.pdf>, in Shapiro, S., Ruttenberg, R., Leigh, P., “The Social Costs of Dangerous Products: An Empirical Investigation,” *Cornell Journal of Law and Public Policy*, Vol 18, No 3, Summer 2009.
- U.S. Environmental Protection Agency, “Reregistration Eligibility Decision (RED) Document for Creosote,” Case 0139, EPA 739-R-08-007, September 25, 2008, https://www3.epa.gov/pesticides/chem_search/reg_actions/reregistration/red_PC-025004_25-Sep-08.pdf, accessed January 22, 2017.
- U.S. General Accounting Office, “Railroad Safety: FRA Needs to Correct Deficiencies in Reporting Injuries and Accidents,” GAO/RCED-89-109, April 1989, <http://gao.gov/assets/150/147609.pdf>, accessed 2016.
- U.S. House of Representatives, Committee on Transportation and Infrastructure, “The Impact of Railroad Injury, Accident, and Discipline Policies on the Safety of America’s Railroads,” 110th Congress, First Session, October 25, 2007, <https://www.gpo.gov/fdsys/pkg/CHRG-110hhrg38568/html/CHRG-110hhrg38568.htm>, accessed October 12, 2016.
- U.S. Railroad Retirement Board, “2015 Annual Report for Fiscal Year Ended September 30, 2014: The Report in Brief,” https://www.rrb.gov/opa/AnnualRprt/report_in_brief.asp, accessed April 30, 2016.
- U.S. Railroad Retirement Board, “An Agency Overview,” January 2017, https://www.rrb.gov/opps/agency_overview.asp, accessed March 12, 2017, p. 2.
- U.S. Railroad Retirement Board, “Disability Annuities for Railroad Employees,” October 2015. https://www.rrb.gov/opa/qa/pub_1510.asp, accessed December 18, 2016.
- U.S. Railroad Retirement Board, “Medicare: for Railroad Workers and Their Families,” RB-20, January 2016.
- U.S. Railroad Retirement Board, “Performance and Accountability Report,” Fiscal Year 2016.

- U.S. Railroad Retirement Board, “Railroad Retirement Benefits Will Increase in 2017,” PR 16-7, October 2016, <https://www.rrb.gov/ops/pr/pr1607.asp>, accessed March 12, 2017.
- U.S. Railroad Retirement Board, “Railroad Unemployment and Sickness Benefits,” UB-9, July 2015.
- U.S. Renal Data System (USRDS), *The 2016 Annual Data Report, Volume 1: Chronic Kidney Disease in the United States*, 2016a, <https://www.usrds.org/adr.aspx>, accessed December 13, 2016.
- U.S. Renal Data System (USRDS), *The 2016 Annual Data Report, Volume 1: Chronic Kidney Disease in the United States, Introduction*, 2016b, https://www.usrds.org/2016/view/v1_00.aspx accessed December 13, 2016.
- U.S. Renal Data System (USRDS), *The 2016 Annual Data Report, Volume 1: Chronic Kidney Disease in the United States, Chapter 1: CKD in the General Population*, 2016c, https://www.usrds.org/2016/view/v1_01.aspx accessed December 13, 2016.
- U.S. Renal Data System (USRDS), *The 2016 Annual Data Report, Volume 1: Chronic Kidney Disease in the United States, Chapter 3: Morbidity and Mortality in Patients with CKD*, 2016d, https://www.usrds.org/2016/view/v1_03.aspx, accessed December 13, 2016.
- U.S. Renal Data System (USRDS), *The 2016 Annual Data Report, Volume 1: Chronic Kidney Disease in the United States, Chapter 4: Cardiovascular Disease in Patients with CKD*, 2016e, https://www.usrds.org/2016/view/v1_04.aspx, accessed December 13, 2016.
- U.S. Renal Data System (USRDS), *The 2016 Annual Data Report, Volume 1: Chronic Kidney Disease in the United States, Chapter 6: Medicare expenditures for Persons with CKD*, 2016f, https://www.usrds.org/2016/view/v1_06.aspx accessed December 13, 2016.
- U.S. Renal Data System (USRDS), *The 2016 Annual Data Report, Volume 1: Chronic Kidney Disease in the United States, Chapter 7: Medicare Part D Prescription Drug Coverage in Patients with CKD*, 2016g, https://www.usrds.org/2016/view/v1_07.aspx, accessed December 13, 2016.
- U.S. Renal Data System (USRDS), *The 2016 Annual Data Report, Volume 2: End-Stage Renal Disease in the United States*, 2016h, <https://www.usrds.org/adr.aspx>, accessed December 13, 2016.
- U.S. Renal Data System (USRDS), *The 2016 Annual Data Report, Volume 2: End-Stage Renal Disease in the United States, Chapter 11: Medicare Expenditures for Persons with ESRD*, 2016i, https://www.usrds.org/2016/view/v2_11.aspx, accessed December 13, 2016.
- U.S. Renal Data System (USRDS), *The 2016 Annual Data Report, Volume 2: End-Stage Renal Disease in the United States, Chapter 12: Part D Prescription Drug Coverage in Patients with ESRD*, 2016j, https://www.usrds.org/2016/view/v2_12.aspx, accessed December 13, 2016.

- U.S. Renal Data System, “Chapter 6: Medicare Expenditures for Persons with CKD,” *2015 ADR Chapters*, https://www.usrds.org/2015/view/v1_06.aspx, accessed March 19, 2017.
- United States Renal Data System, “Costs of ESRD,” Chapter 11, *2013 Atlas of CKD and ESRD*, 2013, <https://www.usrds.org/atlas13.aspx>, accessed March 19, 2017.
- U.S. Social Security Administration, “What is Medicare and who can get it?” n.d.a., <https://faq.ssa.gov/ics/support/KBAnswer.asp?questionID=3771&hitOffset=50+41&docID=5465>, accessed December 14, 2016.
- U.S. Social Security Administration, Office of Retirement and Disability Policy, “An Overview of the Railroad Retirement Program,” *Social Security Bulletin*, Vol 68, No 2, 2008.
- U.S. Surface Transportation Board, reported in “Class I railroad employment up slightly in March,” in *Trains Industry Newsletter*, May 2, 2017, <http://trn.trainers.com/news/news-wire/2017/05/02-class-i-railroad-employment-up-slightly-in-March#.WjWcce3HRWC.ema>, accessed November 22, 2017.
- United Health Care, “The Railroad Employees National Health and Welfare Plan and The National Railway Carriers and United Transportation Union Health and Welfare Plan Summary of Benefits,” M54407, December 2014, received April 2016.
- Van Dieën, J., “Low-back pain, a consequence of cumulative mechanical loading?” May 23, 2014, <http://www.bodyinmind.org/low-back-pain-and-mechanical-loading/>, accessed November 9, 2016.
- Van Zante-de Fokkert, J. et al., “The Netherlands Schedules Track Maintenance to Improve Track Workers’ Safety,” *Interfaces*, Vol 37, No 2, March-April 2007.
- Virokannas, H., “Dose-response relation between exposure to two types of hand-arm vibration and sensorineural perception of vibration,” *Occupational and Environmental Medicine*, 52, 1995. Virokannas, H., “Dose-response relation between exposure to two types of hand-arm vibration and sensorineural perception of vibration,” <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1128226/pdf/oenvmed00065-0044.pdf>, accessed February 15, 2017.
- Virta, L. et al., “Costs of shoulder pain and resource use in primary health care: a cost-of-illness study in Sweden,” *BMC Musculoskeletal Disorders*, 2012, <http://bmcmusculoskeletdisord.biomedcentral.com/articles/10.1186/1471-2474-13-17>, accessed February 2016.
- Virtanen, I.M. et al., “Occupational and Genetic Risk Factors Associated with Intervertebral Disc Disease,” *Spine* 32(10), 2007.
- Viscusi, W.K. and Aldy, J., The Value of a Statistical Life: A Critical Review of the Market Estimates Throughout the World, *Journal of Risk and Uncertainty*, 27:5-76), 2003, cited in U.S Department of Labor, Occupational Safety and Health Administration, “Preliminary Economic Analysis and Initial Regulatory Flexibility Analysis: Supporting Document for the Notice of Proposed Rulemaking for Occupational Exposure to Crystalline Silica,” 2013.

- Visser, A., et al., "The impact of parental cancer on children and the family: a review of the literature," *Cancer Treatment Reviews*, DOI: 10.1016/j.ctrv.2004.06.001, 2004.
- Wang, L., et al., "Reduced Prefrontal Activation During Working and Long-Term Memory Tasks and Impaired Patient-Reported Cognition Among Cancer Survivors Postchemotherapy Compared with Healthy Controls," *Cancer*, DOI: 10.1002/cncr.29737, 2015.
- Wang, P. et al., "Chronic Medical Conditions and Work Performance in the Health and Work Performance Questionnaire Calibration Surveys," *JOEM*, Vol 45, No 12, DOI: 10.1097/01.jom.0000100200.90573.df., December 2003.
- Washington State Department of Labor & Industries, "Examples of costs and benefits of ergonomics," n.d., <http://www.pshfes.org/cba.htm>, accessed 2016.
- Washington State Department of Labor and Industries SHARP (Safety & Health Assessment & Research for Prevention), "Economic Burden of Carpal Tunnel Syndrome," circa 1994, <http://www.lni.wa.gov/safety/research/occhealth/reports/ctsburden/default.asp>, accessed February 9, 2016.
- Washington State Department of Labor and Industries, "Work-Related Carpal Tunnel Syndrome Diagnosis and Treatment Guideline," 2009, 2014, <http://www.lni.wa.gov/ClaimsIns/Files/OMD/MedTreat/CarpalTunnel.pdf>, accessed 2016.
- WebMD, "Chronic Kidney Disease – Cause," n.d.c, <http://www.webmd.com/a-to-z-guides/tc/chronic-kidney-disease-cause>, December 15, 2016.
- WebMD, "How Do You Treat Carpal Tunnel Syndrome," <https://www.webmd.com/pain-management/carpal-tunnel/treat-carpal-tunnel-syndrome#2>, accessed 2017.
- WebMD, "Stages of Chronic Kidney Disease - Topic Overview," n.d.b, <http://www.webmd.com/a-to-z-guides/tc/stages-of-chronic-kidney-disease-topic-overview>, accessed December 14, 2016.
- WebMD, "Your kidneys and how they work," n.d.a, <http://www.webmd.com/a-to-z-guides/function-kidneys#1>, accessed December 15, 2016.
- WebMD, "Carpal Tunnel Syndrome," n.d., <http://www.webmd.com/pain-management/carpal-tunnel/carpal-tunnel-syndrome>, accessed November 30, 2016.
- West, C., Usher, K., Foster, K., Steward, L., "Chronic pain and the family: the experience of the partners of people living with chronic pain," *Journal of Clinical Nursing*, 2012, doi: 10.1111/j.1365-2702.2012.04215.x, (abstract at <https://www.ncbi.nlm.nih.gov/pubmed/22834990>, accessed February 2016).
- Whitman, K., "An Overview of the Railroad Retirement Program," *Social Security Bulletin*, Vol 68, No 2, 2008.
- Whittemore, R., Dixon, J., "Chronic illness: the process of integration," DOI: 10.1111/j.1365-2702.2007.0244.x, 2008.

- Wier, L.M., Elixhauser, A., Pfuntner, A., Au, D.H., “Overview of Hospitalizations among Patients with COPD, 2008,” HCUP Statistical Brief #106, February 2011. Agency for Healthcare Research and Quality, Rockville, MD, <http://www.hcup-us.ahrq.gov/reports/statbriefs/sb106.pdf>.
- Wilder, S., “OSHA’s 35-lb. lifting limit,” *Long-Term Living*, December 9, 2013, <http://www.ltlmagazine.com/blogs/pamela-tabar/oshas-35-lb-lifting0limit?page=2>, accessed September 20, 2016.
- Willis Law Firm, “Silicosis – Silica Dust Exposure to the Railroad Worker,” <http://www.silicosis.com/railroad/>, accessed July 4, 2016.
- Wilson, B., “Work after cancer: what are the options and how can employers help?”, *The Guardian*, April 9, 2014, <https://www.theguardian.com/society/2014/apr/09/work-after-cancer-options-employers>, accessed January 24, 2018.
- World Health Organization (WHO), “Global Initiative for Chronic Obstructive Lung Disease,” *Pocket Guide to COPD Diagnosis*, 2015, http://www.goldcopd.it/material/2015/GOLD_Pocket_2015.pdf, accessed October 10, 2016.
- World Health Organization (WHO), “Global Initiative for Chronic Obstructive Lung Disease: Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease,” Global Initiative for Chronic Obstructive Lung Disease, 2006, http://www.who.int/respiratory/copd/GOLD_WR_06.pdf, accessed October 10, 2016.
- World Health Organization, “Global Initiative for Chronic Obstructive Lung Disease,” *Pocket Guide to COPD Diagnosis*, 2017, <http://goldcopd.org/wp-content/uploads/2016/12/wms-GOLD-2017-Pocket-Guide.pdf>, accessed March 16, 2017.
- World Health Organization, “Health statistics and information systems,” n.d., http://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/, accessed February 15, 2017.
- World Health Organization, “The world health report, Chapter 4, Selected Occupational Risks,” 2002 <http://www.who.int/whr/2002/chapter4/en/index8.html>, accessed 2016.
- Wyld, M.L., Lee, C.M., Zhuo, X., et al., “Cost to government and society of chronic kidney disease stage 1–5: a national cohort study,” *Intern Med J*, 45, 2015.
- Yabroff, K.R., Lund, J. et al., “Economic Burden of Cancer in the US: Estimates, Projections, and Future Research,” DOI: 10.1158/1055-9965.EPI-11-0650, October 2012, U.S. Department of Health and Human Services, HHS Public Access, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3191884/>, accessed September 12, 2017.
- Ybema, J., Kuijter, R., Hagedoorn, M., Buunk, B., “Caregiver burnout among intimate partners of patients with a severe illness: An equity perspective,” *Personal Relationships*, 2002.
- Yourlawyer.com, “Creosote side effects can be linked to liver damage lawsuits,” <http://www.yourlawyer.com/topics/overview/creosote>, accessed December 14, 2016.

Zajacova, A. et al., "Employment and Income Losses Among Cancer Survivors: Estimates From a National Longitudinal Survey of American Families," *Cancer*, DOI: 10.1002/cncr.29510, March 2015.

Zhang, L. et al., "I felt I have grown up as an adult'," *Child: care, health and development*, DOI:10.1111/j.1365-2214.2009.00973.x, February 2009.

APPENDIX I

METHODOLOGY

Three teams of researchers provided the following work for this study:

1. Epidemiology team leader, Dr. David F. Goldsmith, with Dr. Kathy Kirkland, Ms. Grace Barlet, Ms. Judy Chan, and Mr. Michael Frasketi.
2. Ergonomics team leaders Dr. Eckardt Johanning and Dr. Paul Landsbergis, with Mr. Marco Stillo, Mr. Rahul Jain, and Ms. Michelle Davis.
3. Social and economic team leader Dr. Ruth Ruttenberg, economist with Dr. Kathy Mason (sociologist), Dr. Estye Fenton (sociologist), Ms. Karen Lane (anthropologist/librarian), Ms. Maria Obando (occupational safety and health specialist), Mr. Eli Fenton (software engineer).

The Survey

While each of the three groups worked independently, they were bound together by a common survey which was sent to approximately 35,000 current BMWED members and 4,000 active retirees (those with whom BMWED has on-going contact information). The survey was completed by “active” BMWED members (that is, those working or available for work), those out on disability, and those retired due to age or medical condition at the time of the survey. Each person received a letter by mail from BMWED President Freddie Simpson explaining the overall study and the importance of the survey, a cover memo explaining the survey to participants -- and the survey itself if a retiree and an on-line link to the survey if they were an active member. All were given a security protected URL to access the survey. They were required to sign in at a BMWED site to verify their birthdate, zip code, and the last four digits of their social security number, to assure that the respondents were actual members and that no one provided more than one set of responses. They then gained access to the survey at a separate and secure site. No personal identifiers followed the respondent from the BMWED site to the survey site

Participants were encouraged to fill out the survey on-line, in either English or Spanish, but it was also available in hard copy, or they could complete the survey through a confidential telephone interview (in English or in Spanish). No personal identifiers were ever associated with responses. Retirees, while also encouraged to complete the survey on-line, were mailed a hard copy of the survey with a postage-paid mailer for its return. Participants had several months to complete the survey. Current members could also call or email the research staff for a written survey in English or in Spanish conducted by Dr. Ruttenberg or her team members. Of the 5,445 who logged in to the survey, 4,816 answered any of the survey questions in full or in part. The on-line version of the survey had six “pages”: questions 1-10 (page 1), questions 11-16 (page 2), questions 17-24 (page 3), questions 25-52 (page 4), questions 53-57 (page 5, and questions 58-61 (page 6).

Answering the survey questions took 30 to 45 minutes. The survey ascertained work history, injuries and illnesses, and the social and economic impact of work-related injuries and illnesses. The survey was long and detailed. Respondents could skip questions and could submit with any degree of completion.

The survey results were recorded anonymously on-line; by mail, the survey was similarly returned without personal identifiers. Confidentiality for those who took the survey orally by telephone was maintained. The interviewer did ask for the person's identifying information to verify them in the BMWED system. However, this information was never recorded on the survey, and this identifying information was destroyed as soon as the verification was made.

A few mail surveys were returned with an individual's return address on the outside envelope. When this happened, the outside envelope was destroyed before the survey was put in a stack of surveys needing data input. No identifiers followed the survey unless individuals identified themselves within the survey because they had a question they wanted answered. This question was separated from survey and passed on to the appropriate person at BMWED or, in 2 cases, an occupational health clinic near to respondents was located and clinic information was forwarded to that respondent. No identifying information was put into the data base and the written surveys were destroyed once their data were inputted. Thus, for both phone surveys and mail surveys, a participant's name and identity would not be revealed.

Institutional Review Board (IRB) approvals came from both Cook County Hospital and the State University of New York-Downstate. To ensure that the identity of all survey participants is legally protected from discovery, a Certificate of Confidentiality issued by the National Institutes of Health (NIH) was obtained. Responses from this study contain absolutely no individual or identifiable personal information.

Some questions on the survey came from the National Health Interview Survey and the National Quality of Work Life survey to be able to compare BMWED respondents with all employed workers in the U.S. These surveys, by the U.S. National Institutes of Health, are nationally ongoing representative studies, and the answers by BMWED members could be compared to answers by all U.S. respondents.

Of the 5,445 members and retirees who logged in to the survey, 4,816 answered the survey questions in full or in part. There appears to have been some survey fatigue. More questions were answered at the beginning of the multi-page survey (6 pages on-line, with follow-up questions not appearing if they were not relevant, and 15 pages in written form) than at the end. As a result, the number of responses for analysis also was smaller for many of the later questions.

Cleaning Survey Data and Preparing for Analysis of Data. Cleaning the survey data and preparing it for analysis was conducted by Dr. Paul Landsbergis of SUNY-Down State and his graduate students, and by Ms. Grace Barlet. The following steps were taken:

1. Yes/no questions. There were several yes/no questions in the on-line survey that did not have a "no" option (in order to make the on-line survey easier to read). These were question 25 (health problems), question 32 (various chronic diseases), question 34 (central nervous system condition), question 35 (cancer), question 36 (traumatic work injury), question 55 (illnesses or symptoms caused significant financial or other family burden), question 56, and question 57. Therefore, we assessed whether a missing answer meant "no" or was actually missing. To do this, we determined the number of people who answered at least one question on that page of the survey. The result was:

Page Number of Survey	Number of Respondents Answering at Least One Question on that Page
1	4,816
2	4,202
3	4,070
4	3,821
5	3,497
6	3,538

For questions on each page of the survey, we divided the number responding “yes” to a specific health problem by the number of respondents answering at least one question on that page to determine the percent of people with a particular health problem or other condition. These were our best estimates of the percent of members with those problems or conditions. If, instead, we had divided all these health and other questions by 4,816, the resulting percentages of illnesses and other conditions on pages 2-6 of the survey would be smaller than our best estimate.

2. Out-of-range answers. Because of feasibility issues, none of the questions that asked about a year or an age or hours/week (questions 4-8, 15, many parts of questions 9, 11, 16, 25, 32-36) used a drop-down menu. Members typed in their answers. A number of survey respondents typed in answers that were “out of range”, that is, not possible, for example, a “start work” year of 12 or 1898, or “how many years in a job title” as 2014. We examined each typo and recoded it based on what appeared to be the members' intention (for example, we recoded "12" as "2012", and “1898” as “1998”, and “2014” years as “2”). Or, we recoded the typo as "missing" if it was not possible to make an educated guess about the members’ intent.

In addition, for questions 34-36, the following rules were used for coding text responses: if 2 dates were listed, the first one was picked; a check mark was coded as “yes”; “don’t know”, “IDK”, “unknown”, or “?” were coded as “no”; “0” or “N/A” were coded as missing; and “possibly”, “could be”, or “inconclusive” were coded as “maybe”.

3. Coding open text answers. Similarly, question 25 (Health problems diagnosed by a doctor or health provider and possibly related to railroad work) was an open text question (no menu of options) for which we had to create categories of health problems and code, since the same health problem could be and was described in slightly different words. We created 46 categories of health problems, plus an “other” category.

Were Members and Retirees Who Answered the Long Survey Representative of the Membership?

The 2016-17 BMWED health and safety survey was at least partly completed by 4,816 members, approximately 12% of members and retirees. It was important to determine to what extent the members who answered the survey (survey respondents) were representative of all active or retired

members who received the invitation to complete the survey. There were two main methods that we used to examine whether the survey respondents were representative of all members:

- 1) We compared survey respondents to the national membership of the union on available demographic information (age, years on the job, gender, region of country, and railroad).
- 2) We compared survey respondents to a random sample of non-respondents who later agreed to complete a short (10-question) version of the survey by telephone. The ten yes/no questions are in Appendix VII. This telephone survey of members who had not responded to the on-line survey was done by local union officials (to have immediate trust by the members).

Overall, it was found that the members who completed the on-line or paper survey were, on average, younger, and had slightly better working conditions than members who did not complete the survey. Survey respondents also tended to be healthier than non-respondents in their responses on surgeries, cancer, or shortness of breath. However, back pain in the past week was slightly more common in survey respondents.

Therefore, the percent of members who reported injuries and illnesses on the large 2016-17 BMWED survey would probably be somewhat less than the percent that would have been reported by all BMWED active members or retirees if all had completed the survey. This implies that the results we report are likely conservative (lower) estimates of the prevalence of ill health (except for back pain). In addition, these findings suggest that associations between working conditions and the health of BMWED members that we report (except for back pain) are likely underestimates of the true connections that would have been seen if all had completed the survey.

Telephone Interviews

When taking the survey, BMWED members were asked if they would be willing to participate in a more in-depth telephone interview. More than 300 agreed. Interviewers completed 155 of these interviews. Those interviewed were approached in the order in which they volunteered, and within that group, in the order that they could be reached by telephone. They are not demographically representative of either BMWED membership or survey respondents. Just over 75 percent were retirees. (Retirees volunteered disproportionately, were easier to reach, and had no concerns about any possible repercussions for telling their stories.) Of the 25 percent interviewed who were active members, just under 30 percent were out on disability. Whether active, disabled, or retired members, 76 percent had worked for the railroad for 30 or more years. These interviews are part of the study on the social and economic impact of the work-related injuries and illnesses of maintenance-of-way workers.

Focus Groups

Two focus groups were held with BMWED members in the last quarter of 2017. The purpose was to probe the impact of workplace injuries and illnesses on families and communities. The participants, however, were more interested in discussing immediate hazards in their workplaces. All participants pledged to maintain confidentiality of the information they heard from others during their respective session. The sessions were led by the chief author of this report. Notetaking was by the current safety director for BMWED.

Literature Review and Statistical Searches

A robust literature review and statistical search uncovered data on the social and economic impact of illness and injury. Of particular focus in this paper are chronic obstructive pulmonary disease, non-cancerous chronic kidney disease, cancer, back problems, and carpal tunnel syndrome.

Technical Notes

In adjusting dollar values for inflation, the author assumed the December value for both the base year and for December 2016. Calculations were made based on the Bureau of Labor Statistics inflation multiplier. When in doubt about the base year dollar value, the author assumed that the data came from the year prior to publication.

OSHA's Safety Pays Cost Estimator³¹⁸

The costs generated by the OSHA Safety Pays Cost Estimator are per incident. The direct costs are based on average claim costs reported to the National Council on Compensation Insurance and reflect average cost of lost time workers' compensation insurance claims during 2011-2013. Indirect costs are from the Business Roundtable publication, "Improving Construction Safety Performance," based on work by the Stanford University Department of Civil Engineering. The indirect estimates include impacts on wages, overtime, administrative time, training costs, lost productivity and repair and replacement of damaged property. Indirect costs do not include legal actions, third-party liability, pain and suffering, or loss of good will from bad publicity. These numbers were not adjusted for inflation.

Why the Cost Estimates in this Study are Conservative

Every effort was made to underestimate, rather than overestimate, the cost burden of disease and injury. Below are just a few examples. All are mentioned in the narrative of the text.

- Cost estimates are incomplete – not covering retirees, not covering more than the five health issues that are the focus of this paper, not measuring income and retirement losses of caretakers, not including presenteeism of caretakers, not estimating of the burden to widows and orphans, etc. The burden to the RRB of paying for disability and sick benefits is not included, to be sure not to double-count with OSHA's indirect cost estimates.
- Costs are calculated for only five health issues – COPD, chronic kidney disease, cancer, lower back problems, and carpal tunnel syndrome. There are a host of other infirmities that could have been included, ranging from multiple injuries from track-related accidents, amputations, serious cuts and lacerations and bone fractures to rotator cuff problems, hernias, knee replacements, and neurological diseases. To the extent that maintenance-of-way workers suffer more and earlier Alzheimer's (the Goldsmith SMR showed greater than seven-fold risk for those under 65 dying of Alzheimer's), serious additional costs could be added to the economic burdens calculated in this paper.

³¹⁸ U.S. Department of Labor, Occupational Safety and Health Administration, "OSHA's Safety Pays Program: Background of the Cost Estimates," <https://www.osha.gov/dcsp/smallbusiness/safetypays/background.html>, retrieved January 4, 2018.

- Only five years of presenteeism for COPD, CKD, and cancer are calculated. Many workers may be on the job impaired for long periods of their careers. And the number of days of presenteeism used in calculations, 12, is lower than specific diseases documented – 27.5 days for COPD, and 12.3 days for cancer, for example.
- The percentage of people with multiple diseases is probably underestimated. For example, not only are there sources that put the rate of chronic kidney disease in the population at 13 percent to 16 percent, instead of 12.4 percent we used, but, according to the National Kidney Foundation,³¹⁹ heart disease is the major cause of death for all people with CKD, and so the death statistics are, by definition, skewed.

³¹⁹ National Kidney Foundation, “About Chronic Kidney Disease: A to Z Health Guide,” <https://www.kidney.org/atoz/content/about-chronic-kidney-disease>, accessed January 24, 2018.

APPENDIX II

SURVEY PROTOCOL THE BMWED HEALTH AND SAFETY SURVEY

Thank you for responding to this important survey. Over the years, concerns have grown about the potential risks of maintenance of way work (MOW) to your health and safety. In response, the Brotherhood of Maintenance of Way Employees Division (BMWED) is embarking on a major research study, the BMWED Health and Safety Study, to document any such risks and their impact on members and retirees. One part of this research is a survey of the membership. We need your help.

Your survey answers are entirely CONFIDENTIAL, so please be completely candid. **NEITHER THE UNION NOR THE RAILROAD WILL SEE YOUR SURVEY RESPONSES.** Your survey answers will be separated from any personal identifying information to protect your privacy, and then all the anonymous survey responses will be combined together and coded as an additional layer of protection. This procedure will be in place whether you answer by mail, phone, or on the internet. All research work is being done by independent professional researchers from Ruth Ruttenberg & Associates, the State University of New York (SUNY), and the Association of Occupational & Environmental Clinics (AOEC) who will destroy these surveys once the data have been entered into a general data base. Your name and other personal identifiers will not be attached to your survey responses. To help further protect your privacy, we have received a Certificate of Confidentiality from the National Institutes of Health.³¹⁹

We ask that you answer all the questions, but you are free to leave blank any questions with which you are uncomfortable. If you have any additional concerns, issues or ideas that you would like to share, please add them in the “Additional Comments” section at the end of the survey. It should take about 30-45 minutes to complete the survey.

The survey asks for some general information about you and your family. It asks about your current and past health as well as your work history. We will also ask about the impact of any work-related illnesses or injuries on you and your family.

Attached is a paper copy of the survey. Please return your completed survey to Ruth Ruttenberg in the self-addressed envelope provided. If you prefer, you can choose to take the survey anonymously on-line, in English or Spanish, by going to our secure website at **www.bmwesurvey.com**. Or you can request a telephone interview in which your responses will be noted for you. If you answer by mail or phone, anything possibly identifying you with your answers (e.g., return address, phone number, etc.) will be destroyed. We have taken these steps to minimize any risk that personal information could be disclosed. Your privacy is our highest priority as we move forward with this important research.

Your participation in this survey is very important. BMWED will use the findings to help rail workers live longer and healthier lives, and reduce conditions impacting BMWED members’ health and safety through a combination of regulatory improvements and labor/management engagement. However, your participation is completely voluntary. As a way of thanking you, we will enter your name into a raffle

³¹⁹ The researchers can use this Certificate of Confidentiality to legally refuse to disclose information that may identify you in any federal, state, local, civil, criminal, administrative, legislative, or other proceeding; for example, if there is a court subpoena, the BMWED researchers will use the Certificate to refuse any demands for information that might in any way identify you. You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research or from asking researchers in writing to release information to others such as your doctor.

drawing, if you wish. There will be ten BMWED hoodies to be won in the raffle (handled by an independent contractor). Please see the end of the survey for details.

We need your permission in order to begin.

I consent to fill out this questionnaire as a participant in the BMWED Health and Safety Survey.

Yes ☐ No ☐

PLEASE TAKE THE BMWED HEALTH AND SAFETY SURVEY:

If you are answering the enclosed paper survey, please send your completed survey in the envelope provided to: Ruth Ruttenberg and Associates, 1830 Hallstrom Road, Northfield, Vermont 05663.

To answer on-line, go to: **www.bmwesurvey.com**. If you wish, you may take a break from the on-line survey and return to it later. You may answer the on-line survey in English or in Spanish.

To answer in a telephone interview contact Ruth Ruttenberg at 802-485-4554 or at rruttenberg@tds.net.

To answer by telephone in Spanish, or to request a paper survey in Spanish contact Maria Obando at 240-855-2237 or at mariaobando@tds.net. *(Para responder por teléfono en español, o para pedir una copia de la encuesta en español, por favor contacte a Maria Obando al 240-855-2237 o por email a mariaobando@tds.net.)*

If you have any questions about this survey, please contact Rick Inclima, BMWED Director of Education and Safety at 202-508-6449 or ricki@bmwe.org.

Thank you!

I. BACKGROUND INFORMATION

1. Do you currently work for a railroad?

- ☐ Yes
- ☐ No, I retired on a Railroad Retirement Board disability annuity.
- ☐ No, I retired based upon age and service.
- ☐ No, I retired based upon a medical condition.

2. Which railroad company do you now work for, or, if you no longer work, which was the last railroad you worked for?

- | | |
|--|---|
| ☐ Alaska Railroad | ☐ Kansas City Southern |
| ☐ Amtrak | ☐ Norfolk Southern |
| ☐ BNSF | ☐ Soo Line |
| ☐ Commuter Railroad _____(name) | ☐ Tex-Mex |
| ☐ CSX | ☐ Union Pacific |
| ☐ Canadian Pacific | ☐ Other, please list _____ |
| ☐ Canadian National | |

3. In what region of the country did you perform the majority of your railroad work?

- ☐ **NORTHEAST** (CT, ME, MA, NH, NJ, NY, RI, VT, DE, DC, MD, OH, PA, VA, WV)
- ☐ **SOUTHEAST** (AL, FL, GA, KY, MS, NC, SC, TN, AR, LA)
- ☐ **CENTRAL** (IL, IN, MI, MN, WI, IA, CO, KS, MO, NE, OK, TX)
- ☐ **WESTERN** (AZ, CA, NV, UT, ID, MT, NM, ND, OR, SD, WA, WY)

4. In what year did you retire? _____

5. If you've been granted a disability annuity by the Railroad Retirement Board, what year did you leave work? _____

6. How many years have you worked for the railroad as a maintenance of way employee? _____

7. At what age did you begin work for a railroad? _____

8. What year were you born? _____

9. Below are broad categories of railroad jobs. Please indicate which jobs you worked and provide your best estimate regarding the years you worked them:

Job description	Check here if you worked this job	Start Year	Estimated total years you worked this job	Check if you wore a dust mask when working this job			Was there visible airborne dust when working this job?		
				Always	Some times	Never	Always	Some times	Never
Trackman/Laborer									
Machine Operator (hand-held power tools and small walk behind/beside machines)									
Equipment Operator (medium/large, self-propelled on-track/off-track equipment)									
Surfacing Gang Equipment Operator (ballast regulators, tamper, mechanical boom)									
Welder or welder helper									
Foreman (foreman, assistant foreman, section foreman, B&B foreman)									
Track inspector									
Bridge and Building employee (painter, carpenter, ironworker, structural welder, plumber)									
Electric Traction employee (catenary power and 3 rd rail)									
Truck driver/bus driver (CDL driver, boom truck, material truck, gang bus, lowboy truck)									
Roadway equipment mechanic/repairman									
Other (explain _____)									

10. In the past 2 years, approximately how many nights a month did you spend away from home for work?

None ☐ 1-5 nights ☐ 6-10 ☐ 11-15 ☐ 16-20 ☐ more than 21 nights/month ☐

II. WORK HISTORY (Vehicle and Tools)

11. Please tell us if and what vehicles you have operated or been riding on since you started working for the railroad. Please be as specific as possible, but report only if you have done it for more than one year.

Vehicle type	Yes	<u>IF YES,</u>		
		What year did you begin?	About how many years did you do this work?	About how many hours per day?
Ballast Regulator				
Tamper				
Front end loader				
Tie crane				
Crane (American, Ohio, or other:25-80 tons)				
Backhoe				
Grader				
Bulldozer				
Cribber/ Scarifier (tie renewal gang)				
Pettibone				
Brushcutter				
Truck(s) (heavy; road or hi-rail)				
Light truck/van (i.e., F150-350) (road or hi-rail)				
Other, please list _____				

Other Jobs and Activities

12. Did you work at any second (non-railroad) job more than 20 hours per month since you went to work for the railroad? Yes ☐ No ☐

If you are holding a second job (or held one since you began working for the railroad), please complete the following questions. If yes, please answer questions 13 and 14. If no, please go to question 15.

13. If yes, what was the other job?

Occupation: _____

Industry : Construction ☐ Farm/agriculture ☐ Factory work ☐ Services ☐

Year began _____

Estimated total number of years you worked the 2nd job _____

14. For this second job, in the past year, which did you use on a daily basis?

	Yes
a. Car (other than going to and from work)	
b. Van (other than going to and from work)	
c. Bus or Coach (other than going to and from work)	
d. Train (other than going to and from work)	
e. Motorcycle (other than going to and from work)	
f. Rock crusher	
g. Concrete production machinery	
h. Tractor	
i. Loader	
j. Excavator	
k. Bulldozer	
l. Grader	
m. Scraper	
n. Dumper	
o. Other earth-moving machinery	
p. Road roller	
q. Mower (seated)	
r. Off road forestry vehicle	

15. In your spare time (i.e. outside work and going to and from work), please give your best estimate of the total number of hours (or minutes) per week you spend driving or riding in the vehicles listed below.

	Hours Per Week
Car or Van	
Bus or Coach	
Commuter Train	
Motorcycle	
Snowmobiles	
ATVs	
Horseback Riding	
Mountain Biking	
Mower	
Tractor	

6. Please tell us what tool(s) you have used, at work, since you started working for the railroad. Please be as specific as possible, but report only if you have done/handled this for more than one year. Please mark all that apply.

Tool Type	Yes	About how many years have you used these tools?	About how often do you use this (these) tools in a typical day?				
			Always	Often	Some times	Rarely	Never
POWER TOOLS							
Jackhammer							
Rock drill							
Concrete vibrator							
Hammer drill							
Nail gun							
Reciprocating saw							
Rivet buster							
Scabbler							
Air hammer							
Impact wrench							
Nut splitter							
Tamping gun (hand held)							
Profile grinder							
Spike puller							
Spiker gun							
Spike driver							
Rail saw							
Impact tool							
Grinder							
Asphalt tamper							
Rail drill							
Other, please list _____ _____							
HAND TOOLS							
Sledge hammer							
Spike maul							
Claw bar							
Anchor wrench							
Track wrench							
Lining bar							
Clip applicator							
Other, please list _____ _____							

III. WORKING CONDITIONS

17. Please describe how many hours during your work day you face each of the following conditions:

AT WORK:	Always (8-10 hours)	Often (4-6 hours)	Sometimes (1-2 hours)	Seldom (less than 1 hour)	Never (0 hours)
I sit					
I stand					
Vehicle/equipment vibration bothers me					
Hand tool vibrations bother me					
Noise bothers me					

18. How often does your job involve repeated lifting, pushing, pulling, or bending?

Often/Always ☐

Sometimes ☐

Seldom/Never ☐

19. How would you estimate your exposure during your railroad career to ...?

	Extreme	Heavy	Moderate	Light
Ballast dust				
Creosote				
Diesel Fumes				
Herbicides/Pesticides				
Solvents/Chemical Working Fluids				

20. Which of the following best describes the hours you usually work?

- ☐ A regular daytime schedule (most of your shift is between the hours of 6 AM and 6 PM)
- ☐ A regular evening shift (most of your shift is between the hours of 2 PM and midnight)
- ☐ A regular night shift (most of your shift is between the hours of 9 PM and 8 AM)
- ☐ An irregular schedule such as rotating shifts, split shifts, or some other schedule where hours change from day to day or week to week

Rate the Following Statements About Your Feelings on the Job/About Your Job/Work Environment	Strongly Agree	Agree	Disagree	Strongly Disagree
21. My job allows me to make a lot of decisions on my own				
22. I can count on my supervisor or manager for support when I need it				
23. The health and safety of workers is a high priority with management where I work				

24. How often are there not enough people or staff to get all the work done?

Often ☐

Sometimes ☐

Rarely ☐

Never ☐

IV. GENERAL HEALTH STATUS

25. Please list any and all health problems that you think could *possibly* be related to your railroad work, and when the symptoms first emerged. (You can add more at the end of the survey under “Other Comments.”) Examples might include: lung cancer, chronic bronchitis, skin cancers, neurological conditions, joint pain, rotator cuff, crushed finger –but these are just examples.

Health Problem	Year the Symptoms First Emerged
1.	
2.	
3.	
4.	
5.	
6.	
7.	

26. Have you had surgeries since you began working for the railroad? Yes ☐ No ☐

If yes, which ones and at what age?

Type of Surgery	Any Additional Detail About the Type of Surgery	Your Age at Time of Surgery
Back		
Colon		
Elbow		
Eye		
Hip		
Kidney		
Knee		
Neck		
Shoulder		
Skin (melanoma)		
Stomach		
Other (Please describe) _____		
Other (Please describe) _____		

	Yes	No	Inconclusive
27. Have any of your illnesses or symptoms been recognized by a doctor as <u>being</u> work-related? <u>If yes</u> , which ones? _____			
28. Has the railroad disputed your doctor's diagnosis of work relatedness?			
	Yes	No	
29. Do you <u>NOW</u> smoke cigarettes: Every day ☐ Some days ☐ Not at all ☐			
30. <u>If yes</u> , how many cigarettes do you smoke per day? _____ If you no longer smoke, how many cigarettes, at most, did you smoke per day? _____			
31. Have you smoked at least 100 cigarettes in your ENTIRE LIFE?			
	Yes	<u>If yes, how many years have you had this condition?</u>	
32. Have you EVER been told by a doctor or other health professional that you had.....			
Chronic obstructive pulmonary disease, also called COPD?			
Asthma			
A lung disease called silicosis or silico-tuberculosis?			
Hypertension, also called high blood pressure?			
High cholesterol?			
Coronary heart disease?			
Angina, also called angina pectoris?			
A heart attack (also called myocardial infarction)?			
Any other kind of heart condition or heart disease?			
A stroke?			
Arthritis?			
Rheumatoid Arthritis?			
Gout?			
Lupus?			
Fibromyalgia?			
A condition affecting the wrist and hand called carpal tunnel syndrome?			
Diabetes or sugar diabetes?			
Prediabetes, impaired fasting glucose, impaired glucose tolerance, borderline diabetes, or high blood sugar? <u>If yes</u> , how old were you when a doctor or other health professional FIRST told you that you had diabetes or sugar diabetes? _____			
33. DURING THE PAST 12 MONTHS, have you been told by a doctor or other health professional that you had weak or failing kidneys? - Do not include kidney stones, bladder infections or incontinence. <u>If yes</u> , how many years have you had this condition? _____			

	Yes	IF YES,		
		What year diagnosed?	Did a doctor tell you it was work related?	Do you think it was work related?
34. Has a doctor ever told you that you have a central nervous system condition such as?				
Memory issues, Forgetfulness				
Dementia				
Parkinson's disease				
Tremor in your hands or legs				
Tingling or numbness in your hands or legs				
Multiple Sclerosis (MS)				
Lead poisoning				
Mercury poisoning				
35. Has a doctor told you that you have cancer? If so, what kind?				
Bladder cancer				
Brain cancer				
Kidney cancer				
Leukemia				
Lung cancer				
Lymphoma				
Melanoma or other skin cancers				
Pancreatic cancer				
Prostate cancer				
Stomach cancer				
Other cancer (please describe_____)				
36. Have you suffered a severe traumatic work injury resulting in missing work for more than 3 days, such as ...?				
Crushed hand, wrist, or fingers				
Injury to back				
Injury to neck				
Injury to head				
Injury to knees				
Injury to foot/ankle				
Injury to hips				
Injury to shoulders				
Injury to trunk				
Other traumatic injury (please describe_____)				

	Usually	Some- times	Never
37. Do you have shortness of breath when you walk on level ground?			
38. Do you wheeze when you walk on level ground?			
39. Do you have a productive cough when you wake up, more than 3 days per week?			
40. Do you have phlegm production, when you wake up, more than 3 days per week?			

BACK HEALTH

	Yes	No
41. Have you had back pain during the past week?		
42. Do you have lower back pain more than 3 times per year?		
43. Do you have lower back pain lasting more than 1 week at a time?		
44. Did you have any severe injuries or fractures in the area of current discomfort? Please describe: _____		
45. Did your doctor or chiropractor tell you that you had a back problem and/or is treating you for a back problem? <u>If yes</u> , what was the diagnosis? _____		
46. Have you ever reported a back-related injury to the railroad or railroad medical department? <u>If yes</u> , please describe the injury: _____		

47. Within the last week, how often did you have any of the following in your lower back?

	Always (every day)	Often (4-6 days/ week)	Sometimes (1-2 days/ week)	Seldom (up to 1 day/ week)	Never
Pain					
Cramping					
Burning sensation					
Stiffness					
Swelling					
“Pins and Needles”					
Numbness in back only					
Numbness in back and lower leg					

48. During the past year, how often have you had the following experiences? (Please check the best answers)

	Daily	1-2 times a week	1-2 times in a month	1-2 times in a year	Never
Your back pain goes from the lower back down the leg below the knee(s)					
You take any pain medicine for your back problem					
While working for the railroad, have you missed/did you miss 3 or more days of work due to back problems					

49. When you started your present job, did you have back problems?

- ☐ Daily
 ☐ 1-2 times a year
☐ 1-2 times a week
 ☐ Never
☐ 1-2 times in a month

HAND HEALTH

50. How often have you had the following symptoms during the past year? (Please check the best answers.)

	YES				NO, Never
	Daily	1-2 times a week	1-2 times in a month	1-2 times in a year	
Do you have <u>numbness or tingling</u> of the fingers at any time?					
Do you have any <u>numbness or tingling</u> of the fingers lasting more than 20 minutes during or after using vibrating tools?					
Do you wake up at night with pain, tingling, or numbness in your hand or wrist?					
Have any of your fingers gone white (blanching) on cold exposure?					
If you have experienced white fingers, was the whiteness <u>clearly demarcated</u> (showed limits or boundaries)?					
Do you have difficulty picking up very small objects, i.e., screws or buttons or opening tight jars?					

OTHER JOINT PAIN PROBLEMS

51. If you have had severe joint pain in the past week or the past year, please answer the questions below in the boxes.

	During the <u>past week</u> have you had pain lasting a day or more in your ...	During the <u>past 12 months</u> have you had pain lasting a day or more in your ...	During the <u>past 12 months</u> have you been prevented from carrying out normal activities (e.g. job, housework, hobbies) because of pain in your ...
KNEES	Yes ☐	Yes ☐	Yes ☐
HIPS	Yes ☐	Yes ☐	Yes ☐

52. What about severe pain in your upper body parts?

	During the <u>past week</u> have you had pain lasting a day or more in your ...	During the <u>past 12 months</u> have you had pain lasting a day or more in your ...	During the <u>past 12 months</u> have you been prevented from carrying out normal activities (e.g. job, housework, hobbies) because of pain in your ...
SHOULDERS	Yes ☐	Yes ☐	Yes ☐
NECK	Yes ☐	Yes ☐	Yes ☐
WRISTS/ HANDS	Yes ☐ IF YES: Right ☐ Left ☐ Both ☐ Neither ☐	Yes ☐ IF YES: Right ☐ Left ☐ Both ☐ Neither ☐	Yes ☐ IF YES: Right ☐ Left ☐ Both ☐ Neither ☐
ELBOWS	Yes ☐ IF YES: Right ☐ Left ☐ Both ☐ Neither ☐	Yes ☐ IF YES: Right ☐ Left ☐ Both ☐ Neither ☐	Yes ☐ IF YES: Right ☐ Left ☐ Both ☐ Neither ☐

V. IMPACT OF YOUR HEALTH STATUS ON YOU, YOUR FAMILY, AND YOUR COMMUNITY

53. Have you had out-of-pocket expenses associated with work-related illnesses, symptoms, or injuries while working for the railroad? Yes ☐ No ☐

If yes, please answer the questions below about types of expenses and amount.

Type of Out-of-Pocket Expense	Check here if you had this expense	Approximate amount you spent or lost	What illness or injury required this expense?
Medical devices			
Travel to doctors			
Parking			
Over the counter medications			
Prescription medications			
Medical appointment co-pay/co-insurance			
Caretaker/health aide			
Unpaid caretaker's lost wages			
Child care/Elder care			
Other, describe _____			
Other, describe _____			
Other, describe _____			

54. If you have missed work as a result of illnesses or symptoms that might be work related, please answer the questions below.

Type of work related illness or injury for which you missed work	How many days did you miss work since you began BMWWE work	Approximate number of total days that family members missed <u>school</u> to care for you	Approximate number of total days that family members missed <u>work</u> to care for you
<i>Example: kidney disease</i>	<i>40 days</i>	<i>0 days</i>	<i>8 days</i>
1.			
2.			
3.			
4.			
5.			
6.			

55. Have any illnesses or symptoms, that you think are railroad work-related, caused significant financial or other family burden, such as ... (Check all that apply.)

	Yes	<u>If yes,</u> due to what illness or symptom	Any Additional Details
Serious financial hardship			
Cancelled vacation			
Put off buying ... a car ☐ a house ☐ a major appliance ☐			
Had a? car repossessed ☐ a house repossessed ☐ a major appliance repossessed ☐			
Personal bankruptcy			
Mounting credit card debt			
Threatening bill collectors			
You had to take on a second job			
Someone in your household/family had to take on another job to pay bills. If so, who? _____			
Someone in your household/family had to cut back on work or school to take care of you. <u>If so</u> , who? _____			
Needed to purchase home care, day care, or elder care			
Other (Please explain) _____ _____			

56. Have any illnesses or symptoms caused changes in your social interactions? (Check all that apply.)

	Yes	<u>If yes,</u> due to what illness or symptom	Any Additional Details
Can't volunteer or volunteer less, no energy (explain – church, scouts, sports coaching....) _____			
Don't have the energy to go out			
Have given up hobbies			
Have to hire people to do chores around the house or do errands			
Church members or others have to come and help me and/or family			
City, county or state social services are needed to help with family issues			
Don't have as much fun as I used to			
Other (Please explain _____ _____)			

57. Have any illnesses or symptoms caused/contributed to stress in family interactions? (Please explain.) (Check all that apply.)

Check all that apply.	Yes	<u>If yes,</u> due to what illness or symptom	Any Additional Details
Marital stress: (relationship damaged ☐ , separation ☐ , divorce ☐)			
Children moving back in to help out			
Children moving out			
A parent or in-law needing to move in to help out			
Partner having to take on a new job to help with expenses			
Partner having to quit a job to take care of you			
Child having to postpone/ drop out of school for caretaking and/or income earning related to illness			
Child with lower grades in school			
Not being able to go to children's activities			
Mental health issues: (Self ☐ , spouse ☐ , child ☐ , other _____)			
Substance abuse: (Self ☐ , spouse ☐ , child ☐ , other _____)			
Other (Please describe) _____ _____			

DEMOGRAPHIC QUESTIONS

58. What is your gender? Male ☐ Female ☐

59. Which of the following best describes your racial/ethnic background?

☐ African-American☐ Hispanic☐ Asian☐ Native American☐ Caucasian☐ Other _____

60. What is your BMWED Local number? _____

(This number will be encrypted, so that only the researchers can match the encryption with your real lodge number.)

61. Other comments related to your health status or elaboration of comments already written.

This image shows a single sheet of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

(Feel free to write more if you wish.)

Please Note: If you have any pictures of hand tools that bother you in particular, please send us a picture. Please send to: Ruth Ruttenberg, 1830 Hallstrom Road, Northfield, VT 05663 or rruttenberg@tds.net.

We are very interested in hearing your stories in more detail. If you are willing to talk with us, by phone or email, please provide your name, phone number and email here. (To protect the confidentiality of your answers, this page, with personal information, will be stored totally separately from your answers to the survey questions. There will be no way to associate your name with the answers you have provided above. If you are filling this out on paper, rather than on line, please send the information below in a separate envelope to our independent contractor Ruth Ruttenberg, 1830 Hallstrom Road, Northfield, Vermont 05663 or email to rruttenberg@tds.net.) Our hope is to collect this more detailed information from hundreds of BMWED members and retirees, so as to better describe the full impact of workplace injuries and illnesses. No one will be identifiable in the final report.

Name _____

Telephone Number _____

A good time to call _____

Email _____

APPENDIX III

MAP OF ZIP CODES FROM WHICH BMWED MEMBERS RESPONDED TO THE SURVEY*



* LODGES FROM 48 STATES THAT 2,240 WORKERS SAID THEY WERE FROM (no zip codes were available for lodge number of 285 workers and many did not provide a lodge number.)

APPENDIX IV

EMPLOYMENT BENEFITS AVAILABLE TO RAIL WORKERS

Wages and Benefits

The follow is the compensation package for 2017 for BMWED members:³²¹

Paid By the Carrier	Per Year	Per Month
Wages	\$58,094.40	\$4,841.40
Railroad Retirement Tier I & Medicare (7.65%)	\$4,444.22	\$370.35
Railroad Retirement Tier II (13.1%)*	\$7,610.37	\$634.20
Unemployment (RUIA) (2.15%)**	\$398.64	\$33.22
Railroad Employees' National Health & Welfare Plan ***	\$20,324.64	\$1,693.72
Vision Plan	\$101.28	\$8.44
Dental Plan (GP-12000)	\$781.44	\$65.12
Retiree Health Plan (GA-46000)	\$2,001.00	\$166.75
Supplemental Sickness Benefits (GP-7000)	\$480.00	\$40.00
Off-Track Vehicle Insurance	\$5.40	\$0.45
Employee Cost-Sharing Health Insurance Contribution	-\$2,746.68	-\$228.89
Employee Railroad Retirement Tier I & Medicare (7.54%)*	-\$4,444.22	-\$370.35
Employee Railroad Retirement Tier II (4.9%)*	-\$2,846.63	-\$237.22
Total Employer Paid Cash, Non-Cash Compensation and Payroll Taxes Less Employee Cost-Sharing and Employee Payroll Taxes	\$84,203.86	\$7,016.99

*All Tier I and Tier II payments are based on the \$228.89.00 monthly cost-sharing payment being deducted prior to the calculation of payroll taxes.

**The RUIA tax rate is based upon each railroad's experience (the more claims for unemployment insurance, the higher the rate) and can vary from 0.65% to 12% of a maximum monthly wage of \$1,545.00. For purposes of this chart, the figure of 2.15% is used. The actual rate for employees will vary by employer.

***Includes both foreign to occupation and on-duty coverage, life insurance, and accidental death and dismemberment coverage.

Hourly wage, with straight time hours, for 2017, is \$27.93.³²²

Retirement, Survivor, Unemployment, and Sickness Benefits

The U.S. Congress established the Railroad Retirement system in the 1930's, which is primarily administered by the Railroad Retirement Board. The program provides retirement, survivor, unemployment, and sickness benefits to eligible railroad workers.³²³

³²¹ Brotherhood of Maintenance of Way Employees Division, IBT, "Memo to All BMWED Division and System Officers from President Freddie N. Simpson," on compensation package, March 10, 2017.

³²² Ibid.

³²³ U.S. Social Security Administration, Office of Retirement and Disability Policy, "An Overview of the Railroad Retirement Program," *Social Security Bulletin*, Vol 68, No 2, 2008.

Pension

Railroad retirement offers unemployment and sickness benefits, as well as Tier II benefits, which resemble private pensions.³²⁴ Tier I benefits are similar to Social Security. In January 2017, the average retirement annuity rose by \$6 a month to \$2,628 and the average combined benefits for an employee and spouse increased \$9 to \$3,815.³²⁵ Full age annuities are for those 60 years old with 30 years of service or at 62 at a reduced rate until one reaches full retirement age.³²⁶

Disability Benefits. RRB and Social Security use the same definition and the same formula for disability benefits. In addition to total disability, RRB provides an occupational disability benefit that does not exist in Social Security. The occupational disability benefit is for when a worker cannot work in their regular railroad job, vs. total disability, which prevents a person from working any job.

Unemployment and Sickness Insurance Benefits

The Railroad Retirement Board administers the Railroad Unemployment Insurance Act and portions of the Social Security Act and Medicare that are designated for rail workers. For the year July 1, 2015 through June 30, 2016, the maximum daily benefit was \$72 with a biweekly maximum of \$720. The payment is granted if the worker is unemployed and able to work or sick and unable to work. Sickness claims are applicable after four consecutive days of sickness.³²⁷ Beginning in July 2016, monthly earnings of up to \$1,879 for up to 26 weeks are the maximum payment. With more than 10 years of service, another 65 days of benefits is possible.³²⁸ Sequestration reductions, however, reduced unemployment and sickness insurance benefits from October 1, 2015 through September 30, 2016, by 6.8 percent, and for fiscal year 2016, by 6.9 percent (beginning October 2, 2016).³²⁹

Medicare for Rail Workers and Their Families

Medicare covers railroad workers just like others covered under Social Security. Railroad retirement payroll taxes include a Medicare hospital insurance tax just like the Social Security payroll tax.³³⁰ Eligibility comes with age 65, four months after total disability, or the 30th month after an occupational disability and a disability freeze, diagnosis of permanent kidney failure or

³²⁴ Whitman, K., "An Overview of the Railroad Retirement Program," *Social Security Bulletin*, Vol 68, No 2, 2008, p.43.

³²⁵ U.S. Railroad Retirement Board, "Railroad Retirement Benefits Will Increase in 2017," PR 16-7, October 2016, <https://www.rrb.gov/ops/pr/pr1607.asp>, accessed March 12, 2017.

³²⁶ U.S. Railroad Retirement Board, "An Agency Overview," January 2017, <https://www.rrb.gov/opps/agency/overview.asp>, accessed March 12, 2017, p. 2.

³²⁷ U.S. Railroad Retirement Board, "Railroad Unemployment and Sickness Benefits," UB-9, July 2015, p.3.

³²⁸ Ibid., p.4.

³²⁹ U.S. Railroad Retirement Board, "Performance and Accountability Report," Fiscal Year 2016, p. 3.

³³⁰ U.S. Railroad Retirement Board, "Medicare: for Railroad Workers and Their Families," RB-20, January 2016.

ALS. Premiums are mostly \$121.80 a month, with a hospital insurance deductible of \$1,288. The 2016 deductible is \$166 and then Medicare usually pays 80 percent of covered services for the rest of the year. Medigap insurance is available as is voluntary Medicare prescription insurance coverage.

Supplemental Sickness Benefit Plan

This plan was negotiated with the railroads and applies for periods of disability beginning on or after July 1, 2012. During any period that an individual is eligible for Railroad Unemployment Insurance Act Sickness Benefits, one can file for these benefits – which ranged in 2015 from \$45 to \$106 per day.³³¹

Financing of the Railroad Retirement Board Benefits

Retirement benefits under the Railroad Retirement Act are funded through payroll taxes on railworkers, Social Security transfers and interest from the National Railroad Retirement Investment Trust, federal income taxes and general fund transfers. In FY 2013, the Railroad Retirement Board paid approximately \$11.6 billion to approximately 568,000 beneficiaries,³³² or approximately \$20,423 per beneficiary.

Financing of Retirement Benefits Under the Railroad Retirement Act, 2010			
Source	Percent of Total	Estimated Dollar Amount Per Person (based on \$18,557 per beneficiary) 2010 dollars	Estimated Dollar Amount Per Person (based on \$18,557 per beneficiary) 2016 dollars
A. Payroll Taxes	44%	\$8,165	\$8,987
B. Social Security	37%	\$6,866	\$7,557
C. Transfers and Interest from the National Railroad Retirement Investment Trust	15%	\$2,784	\$3,064
D. Federal Income Taxes	3%	\$557	\$613
E. General Fund Transfers	2%	\$371	\$408

Source: U.S. Congressional Research Service, “Railroad Retirement Board: Retirement, Survivor, Disability, Unemployment, and Sickness Benefits,” RS22350, January 10, 2011, http://greenbook.waysandmeans.house.gov/sites/greenbook.waysandmeans.house.gov/files/RS22350_gb_0.pdf, accessed August 2016.

Every railroader not yet receiving benefits saves the Railroad Retirement Board \$12,051 (A, C). It saves the Social Security Fund \$7,557 (B) and, it saves federal tax payers \$1,021 (D, E).

³³¹ Ibid.

³³² U.S. Congressional Research Service, “Railroad Retirement Board: Retirement, Survivor, Disability, Unemployment, and Sickness Benefits,” Congressional Research Service, RS22350, September 1, 2014, http://greenbook.waysandmeans.house.gov/sites/greenbook.waysandmeans.house.gov/files/RS22350_gb_0.pdf, accessed March 16, 2017.

APPENDIX V

TABLES OF SURVEY RESULTS ASSOCIATED WITH SOCIAL AND ECONOMIC COSTS TO WORKERS AND THEIR FAMILIES*

Table A: Expenditures of 150 Rail Workers on Medical Devices For Work-Related Injuries and Illnesses		
Amount of Expenditure	Number of Individuals	% of Individuals
Less than \$500	85	56.7
\$500-\$999	29	19.3
\$1000-1999	21	14.0
\$2000-\$4999	5	3.3
\$5000-\$9999	3	2.0
\$10,000 or more	7	4.7
TOTAL	150	100%

Table B: Expenditures of 324 Rail Workers on Travel to Doctors For Work-Related Injuries and Illnesses		
Amount of Expenditure	Number of Individuals	% of Individuals
Less than \$500	180	55.6
\$500-\$999	71	21.9
\$1000-1999	38	11.7
\$2000-\$4999	22	6.8
\$5000-\$9999	8	2.5
\$10,000 or more	5	1.5
TOTAL	324	100%

Table C: Expenditures of 279 Rail Workers on Over-the-Counter Medications For Work-Related Injuries and Illnesses		
Amount of Expenditure	Number of Individuals	% of Individuals
Less than \$500	186	66.6
\$500-\$999	38	13.6
\$1000 or more	55	19.7
TOTAL		99.9

Table D: Expenditures of 265 Rail Workers on Medical Appointment Co-Pays/Co-Insurance For Work-Related Injuries and Illnesses		
Amount of Expenditure	Number of Individuals	% of Individuals
Less than \$500	80	30.2
\$500-\$999	58	21.9
\$1000 or more	127	47.9
TOTAL	265	100%

Table E: Expenditures of 286 Rail Workers on Prescription Medications For Work-Related Injuries and Illnesses		
Amount of Expenditure	Number of Individuals	% of Individuals
Less than \$500	168	58.7
\$500-\$999	38	13.3
\$1000 or more	80	28.0
TOTAL	286	100%

Table F: Days Lost Due to Injury and/or Illness		
Amount of Time Lost	Number Responding	% Responding
A week or less	111	16.4
More than a week, up to a month	161	23.9
More than a month, up to 3 months	223	33.0
More than 3 months, up to 6 months	92	13.6
More than 6 months, up to a year	57	8.4
More than a year, but less than two years	28	4.1
Two years or more	3	~
TOTAL	675	99.4%

* Source: On-line survey

APPENDIX VI

UNDERREPORTING OF INJURIES AND ILLNESSES

Many maintenance-of-way workers report being afraid to report injuries and illnesses to their employer for fear of being taken out-of-service. A major issue throughout survey responses was the assumption that reporting an injury or illness would jeopardize one's employment. Many report having surgeries on vacation time so the railroad would not know of their knee or back injuries caused by the work for the railroad. These survey results are supported by a 2007 Congressional Hearing³³³ which documented frequent harassment of those who report accidents resulting in a significant underreporting of accidents. (This also caused a double bind for injured workers, because many faced disciplinary actions if they later reported an incident, since most rules require 24-hour reporting.) Focus group participants emphasized the fact the railroaders do not report the majority of injuries because they fear being taken out-of-service and/or losing pay.

For years, the reliability of the Federal Railroad Administration injury data base has been questioned. In 1989, a GAO report concluded that "FRA... has little assurance that its injury and accident data base is reliable because the railroads GAO visited were not reporting accurately or completely."³³⁴ According to GAO, injuries involving lost workdays were underestimated by 269 percent, the severity of injuries was understated, and the cost of damages due to accidents was understated by 52 percent.³³⁵

According to a Washington State study, 54 percent of employees indicated that they had experienced and failed to report an accident in the previous year. The study reported that the leading consequences for reporting accidents or injuries were: being blamed for the incident; receiving unfair discipline; being mistreated in some other way; receiving an unfair performance evaluation; being given less favorable duties.³³⁶

Non-reporting is a major problem in rail. A Congressional inquiry³³⁷ concluded that, "the accuracy of the databases for rail safety has been criticized by a number of government reports... Reports have documented a long history of under-reporting of accidents...because employees frequently

³³³ U.S. House of Representatives, Committee on Transportation and Infrastructure, "The Impact of Railroad Injury, Accident, and Discipline Policies on the Safety of America's Railroads," 110th Congress, First Session, October 25, 2007, <https://www.gpo.gov/fdsys/pkg/CHRG-110hhrg38568/html/CHRG-110hhrg38568.htm>, accessed October 12, 2016.

³³⁴ U.S. General Accounting Office, "Railroad Safety: FRA Needs to Correct Deficiencies in Reporting Injuries and Accidents," GAO/RCED-89-109, April 1989, p. 2, <http://gao.gov/assets/150/147609.pdf>, accessed 2016.

³³⁵ Ibid., pp. 3, 17.

³³⁶ Probst, T., Estrada, A., "Accident under-reporting among employees: Testing the moderating influence of psychological safety climate and supervisor enforcement of safety practices," *Accident Analysis and Prevention*, 42, doi:10.1016/j.aap.2009.06.027, 2010, p. 1442.

³³⁷ U.S. House of Representatives, Committee on Transportation and Infrastructure, "The Impact of Railroad Injury, Accident, and Discipline Policies on the Safety of America's Railroads, October 25, 2007.

report ... harassment of those who do report incidents [or] being hurt on the job ... is a common practice in the rail sector.” Survey, interview, and focus group comments all corroborate the serious underreporting problem that exists in the rail industry for reporting accidents and illnesses.

In the nation generally, the Bureau of Labor Statistics estimates an undercount of 20 percent to 70 percent of workplace accidents.³³⁸ Some say it is even more. There are indications, for example, across industries, that even fatal traumatic work-related injuries can go unreported – as many as 40-70 percent of fatal events according to Professor Les Boden of Boston University’s School of Public Health.³³⁹

One study found only 11 percent of those who self-reported MSDs of the hand, arm, and neck filed a workers’ compensation claim. They also found that while there were an estimated 2.8 million cases of occupational asthma in 2007 alone, BLS reported an annual average of only 400 days-away-from-work cases due to allergic asthma in private industry.³⁴⁰

³³⁸ Ruser, J., “Examining evidence on whether BLS undercounts workplace injuries and illnesses,” *Monthly Labor Review*, August 2008, <http://www.bls.gov/opub/mlr/2008/08/art2full.pdf>, retrieved 2008.

³³⁹ Boden, L., “How Often Do Workplace Injuries Go Unreported,” Harvard Catalyst Biostatistics Program Seminar, March 21, 2012, p. 4, <https://catalyst.harvard.edu/docs/biostatsseminar/Boden-Catalyst0312fin.pdf>, accessed 2016.

³⁴⁰ Bushnell, P.T., Li, J., Landen, D., “Group Medical Claims as a Source of Information on Worker Health and Potentially Work-Related Diseases,” *JOEM*, Vol 53, No. 12, DOI: 10.1097/JOM.0b013e3182363bbe, December 2011, p. 1430, abstract at <https://www.ncbi.nlm.nih.gov/pubmed/22076036>, accessed February 2016.

APPENDIX VII

QUESTIONNAIRE PROTOCOL FOR NON-RESPONDERS TO ON-LINE SURVEY

Brother/Sister: You chose not to take the BMWED Health and Safety Survey, and we respect your choice. Over 4,000 of your fellow members did take the survey. I have 10 brief questions to ask you as a non-respondent to our Safety and Health Survey. This will help us to scientifically validate whether or not the 4,000 members who took the survey are “representative” of BMWED members as a whole (both current rail employees and retirees). I will not record your name with your answers, and I will not record any personal identifiers. Would you please help me out by answering these 10 very brief questions?

SAMPLE SURVEY TO TEST REPRESENTATIVENESS OF UNION-WIDE SURVEY

1. Have you had surgeries since you began working for the railroad? Yes___ No___
2. Has a doctor told you that you have cancer? Yes___ No___
3. Have you EVER been told by a doctor or other health professional that you had asthma? Yes ___ No ___
4. Hand tool vibrations bother me: Always ___ Often ___ Sometimes ___ Seldom ___ Never ___
5. How would you estimate your exposure during your railroad career to ballast dust?
Extreme___ Heavy___ Moderate___ Light
6. Have you smoked at least 100 cigarettes in your ENTIRE LIFE? Yes ___ No ___
7. Have you had back pain during the past week? Yes ___ No ___
8. During the past week have you had pain lasting a day or more in your wrists/hands? Yes___ No___
9. How old are you? _____
10. In what state do you/did you do most of your work? _____

Interview conducted by: _____ (BMWED Rep)

Interview date: _____