



ISSN: 0975-833X

Available online at <http://www.journalcra.com>

International Journal of Current Research
Vol. 11, Issue, 12, pp.9091-9096, December, 2019

DOI: <https://doi.org/10.24941/ijcr.37365.12.2019>

**INTERNATIONAL JOURNAL
OF CURRENT RESEARCH**

RESEARCH ARTICLE

THE SOCIAL AND ECONOMIC IMPACT OF LOWER BACK PROBLEMS AMONG RAILROAD MAINTENANCE-OF-WAY EMPLOYEES

***Ruth Ruttenberg, Ph.D.**

Ruth Ruttenberg and Associates and Rutgers University

ARTICLE INFO

Article History:

Received 14th September, 2019
Received in revised form
28th October, 2019
Accepted 29th November, 2019
Published online 31st December, 2019

Key Words:

Lower Back Problems, Maintenance-of-Way Railroad Workers, Occupational Safety and Health, Economic Impact, Social Impact.

Copyright © 2019, **Ruth Ruttenberg, Ph.D.** This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Citation: **Ruth Ruttenberg, Ph.D.** 2019. "The social and economic impact of lower back problems among railroad maintenance-of-way employees", *International Journal of Current Research*, 11, (12), 9091-9096.

ABSTRACT

Thousands of railroad maintenance-of-way (MOW) workers develop lower back problems from their work. This study calculates the social and economic burdens of these problems, borne by thousands of MOW workers. Economic calculations are derived from the literature and also from a survey of 4,800 MOW respondents, 155 in-depth interviews, and two focus groups. This one health problem alone costs at least \$717 million to \$1.103 billion over the course of lower back cases currently diagnosed among MOW workers. Many individuals work through significant pain or have to leave their profession. Some are crippled for life. When a worker has lower back problems, beyond pain and suffering, there are often financial burdens that affect families, railroad companies, insurers, communities, and taxpayers as well as the injured workers.

INTRODUCTION

Maintenance-of-way workers have an increased risk of developing lower back problems. Thousands of railroad maintenance-of-way (MOW) workers develop lower back problems from their work. This one health issue alone costs \$717 million to \$1.103 billion over the course of those back cases currently diagnosed. What follows is a study of MOW workers – their illnesses and the suffering and burdens they endure. While the health impact is clearly the most serious, the objective of this paper is to measure the social and economic impacts of these infirmities. When a worker has a lower back problem, beyond pain and suffering, there are often financial burdens that affect families, railroad companies, insurers, communities, and taxpayers as well as injured workers. These burdens include not only direct medical costs of treatment but also other related costs like over-the-counter medical devices and medications, caretaking, lower productivity of affected workers, lost work time and thus reduced income and future Social Security benefits, psychological stress on individuals and their families, and a host of other factors discussed herein. The work that follows calculates the burden of the lower back problems borne by thousands of MOW workers and many other groups as well.

***Corresponding author: Ruth Ruttenberg, Ph.D.,**
Ruth Ruttenberg and Associates and Rutgers University

MOW workers face significant risks to their health and safety on a daily basis. Maintaining the track is one of the most dangerous jobs facing railroad workers (Van Zante-de Fokkert et al., 2007) with many dying in workplace accidents. In addition, MOW workers constantly bend, twist, and do heavy lifting, thus putting themselves at high risk of injuring their necks, shoulders, knees, 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 illnesses, even death, related to toxic chemical exposures. MOW workers are more likely than the general public, for example, to develop cancer, kidney disease, and carpal tunnel syndrome. Back problems are a serious health problem for them, but only one among many.

MATERIALS AND METHODS

An overall social and economic impact study, of which this is just one of five parts – reviewed cancer, chronic obstructive pulmonary disorder (COPD), chronic kidney disease, and carpal tunnel syndrome, in addition to lower back problems. The economic and social impact study itself was part of a larger assessment, funded by the Brotherhood of Maintenance Way Employes (BMWED), that also included research on epidemiological and ergonomic and physical hazards. 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. Results of this study contain absolutely no individual or identifiable personal information. Informed consent was received for a survey, interview, and focus group participants. The entire membership of BMWED, both active workers and retirees, was invited to participate in a research survey. Of roughly 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. They responded to the survey on-line, in writing, or orally over the telephone, in either English or Spanish. Their credentials as BMWED members or retirees were verified to determine their eligibility to participate. All data were verified and recorded based on numbers responding and the demographics of those responses. Because participation was entirely voluntary, not every participant responded to every question.

To determine the representativeness of survey respondents, they were compared to the national membership of the union based on age, years on the job, gender, region of country, and railroad. In addition, survey respondents were compared to a random sample of non-respondents who later agreed to complete a short (10-question) version of the survey by telephone. Those members who completed the 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. Therefore, the percent of members who reported injuries and illnesses on the large 2016-2017 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, implying that the results reported in this paper are likely conservative (lower) estimates of the prevalence of ill health that would have been seen if all had completed the survey. In addition, for this social and economic impact study, 155 in-depth interviews and two focus groups provided further worker input. The study also includes an extensive literature review, highlighting both related health issues and their economic and social impact. Calculations for economic and social costs are developed in the narrative of the article and corroborated by survey, interview, and focus group comments. The full report and all data are available on request and contain detailed methodology and cost calculations.

The population responding was 99 percent male. Among them, 82 percent were Caucasian, 6 percent African American, 6 percent Hispanic, and 2 percent Native American (25 percent did not designate their race and four percent of those who did stated a mixed race). The BMWED represents union workers who build and maintain the tracks, bridges, buildings, and related infrastructure on all Class 1 railroads in the United States. They work on road gang crews covering 300,000 miles railroad track.

Limitations: 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 geography. This is especially the case for allocation of burden among employers, private insurers, workers compensation, and Federal Employers Liability Act (FELA)-sanctioned legal

compensation. Calculations in this paper do not include thousands of MOW retirees, many of whom suffer from (and according to the survey, at a higher rate than active members) nor do they include non-represented MOW workers.

RESULTS AND DISCUSSION

“My back is shot” is the refrain of many railroad track workers. Back pain is the most prevalent and most costly work-related muscular-skeletal disorders (MSD). (U.S. Department of Health and Human Services, 1997) It is the sixth most costly medical condition in the U.S., and it is responsible for the most lost work days. (Chandwani, 2013) According to the American Chiropractic Association, (American Chiropractic Assn, n.d.) low back pain is the leading cause of disability worldwide, and in the United States 31 million people experience back pain at any given time. It is also a significant social problem in the United States and other industrialized nations because of the pain, suffering, and disability it causes.

Description and Progression of Lower Back Pain and Disability: LBP often becomes a lifelong condition, with different stages of the disorder and different patterns of pain intensity or disability throughout life. (Miedama, 2016). 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 social issues affect the prognosis for lower back pain (Miedama, 2016). Chronic lower back pain creates both financial and emotional problems for the individual and his/her family, including conjugal problems (Mathew et al, 2013). 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 (Miedama, 2016). According to one survey respondent: “Back and leg pain all the time. Pain scale 7-8.” Kovacs et al. (2005) found that the longer lower back pain lasts, the more likely the victim is to become disabled. They report that lower back pain: “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.”

Causes of Lower Back Pain and Disability: According to the Bone and Joint Initiative (2016a) injuries to the trunk (not including shoulder) were the second highest source of work-related injuries in the United States. Virtanen et al. (2007) 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. (2014) 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.”

Table 1. 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 \$)
Direct and Indirect Costs (as estimated by OSHA)	\$130,000	\$568.8
Presenteeism* (12 days a year, assumed to be working on the job for 5-20 years with the affliction)	\$163,782-203,997	\$716.5-\$1,102.6
Unpaid Caretaker Wages (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
Out-of-Pocket Caretaker Expenditures (at \$6,402 per caregiver and 10% of excess cases, (4,375), for 5 years)	\$3,201	\$14.0
Out-of-Pocket Expenditures by the Worker for 5-20 years (1/2 ave. caretaker amount = \$3,201 x 5 years)	\$16,005-\$64,020	\$70.0-\$280.0

*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.

One interviewee for this study 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 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 Dieën (2014) 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: 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. In sum, lifting and lowering materials, frequent bending and twisting and vibration of the whole body are work-related factors that lead to lower back pain.

Economic and Social Impact of Lower Back Pain and Disability: Lower back pain is the most pervasive work-related problem for maintenance-of-way workers, and, indeed, for workers generally. 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. Traditionally, the economic impact of injury and illness focuses 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 workdays as an indirect cost. Absenteeism is one important factor affecting productivity. While absenteeism is more often being measured, rarely measured is the economic burden of “presenteeism,” (Wang et al., 2003) 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 is the presenteeism of caregivers calculated, or even mentioned – workers who often are exhausted and may need to use work time for making arrangements for their injured or sick loved ones. There is 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.” (Jinnett et al., 2016)

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 the Bone and Joint Initiative (2016b) treatment for spine conditions across the U.S. rose 52 percent between 2001 and 2011 to an annual cost of \$284.4 billion in 2011 dollars, or \$304.3 billion in 2016 dollars. Most of this rise was due to the cost of prescription medications. Hospitalization alone for those with spine problems cost \$75.8 billion in 2011, or \$81.1 in 2016 dollars, and patients were two times as likely to be discharged to a long-term care facility as patients with other health problems. According to PhD research by Chandwani, 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. (2013). Chandwani concludes that the high cost of chronic back pain might motivate a change in policy to improve care and outcomes. Indirect economic costs for lower back pain include legal fees, transportation, specialized chairs and mattresses, home modifications, and physical aids. According to the Bone and Joint Initiative (2016a), 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 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 its 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. (2016a) A study on the burden of musculoskeletal diseases in the U.S found that from 2009 to 2011, the average earnings loss due to MSDs was \$2,063, or \$2,201 in 2016 dollars. (Bone and Joint Initiative, 2016)

According to Ricci et al. (2006), Stewart et al. (2003), and the American Academy of Pain Medicine webpage (n.d.), back complications (exacerbations) are costly to the workplace:

- Back pain (BP) in workers 40 to 65 years of age costs employers an estimated \$7.4 billion per year.
- 71.6 percent of this cost is due to workers with BP exacerbations.

- 42.6 percent of all workers reported BP exacerbations, even though BP prevalence is associated with demographic factors.
- Workers with exacerbations reported more days with BP than those without exacerbations.
- Workers with exacerbations were significantly more likely than those without such exacerbations to report activity limitation (88.4 percent vs. 60.7 percent; $P < 0.0001$) and BP-related lost productive time (22.1 percent vs. 13.0 percent; $P = 0.0259$).

Although Gaskin and Richard do not focus on lower back pain, they provide us some general information about the costs of pain in general. Using 2010 dollars and data, they found that the incremental costs for medical care rise as the severity of the pain increases. Estimates of medical costs for moderate pain ranged from \$1,832 to \$2,146 (or \$2,018 to \$2,364 in 2016 dollars) per year, for severe pain from \$2,572 to \$3,956 (or \$2,833 to \$4,358 in 2016 dollars), and for those functionally disabled by pain from \$3,590 to \$3,786 (or \$3,954 to \$4,170 in 2016 dollars). The ranges of cost depended on whether or not functional disability, asthma, and diabetes were included in the calculations. (2012) Gaskin and Richard also calculated indirect costs associated with wage reductions due to different levels of pain. They found that for the 14.1 million people experiencing moderate pain, the indirect costs due to wage reductions ranged from \$21,780 to \$35,795 in 2010 dollars, or \$23,991 to \$39,429 in 2016 dollars.

For the 15.6 million people experiencing severe pain, the indirect costs due to wage reductions ranged from \$40,173 to \$78,214 in 2010 dollars. For the 14.9 million people who were functionally disabled by pain, the indirect costs ranged from \$129,577 to \$130,029 in 2010 dollars (or \$142,733 to \$143,231 in 2016 dollars). Again, the range of cost depended on whether functional disability, asthma and diabetes were included in the computations (Gaskin and Richard, 2012). OSHA in its Safety Pays Estimator (OSHA, n.d.) calculates 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 sales needed to pay for each case would be between from \$315,000 and \$533,000. For all cases it would be between \$1.1 million and \$5.9 million.

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 they were a little worse. (Mathew et al., 2013) 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 being affected negatively. (Mathew et al., 2013) One interviewee for this study spoke for many, saying it is now very hard for him to do stuff around the house and yard and he is very limited because of his back.

Costs of Lower Back Pain to the BMWED Membership and to Individuals:

One rail study already cited in this report (Ganasegeran et al., 2014) found 69 percent of rail workers (likely higher for maintenance-of-way workers) experienced lower back pain at least once a month. A study of U.S. railroad locomotive engineers (Johanning et al., 2004) 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 for this study found that back pain was a common condition, either lower back pain more than 3 times per 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%) were there “severe injuries or fractures in the area of current discomfort”. Therefore, most cases of low back pain were likely chronic conditions due to day-to-day physical work demands. Only in a small percent of cases (5.3%) did members or retirees report having back problems when they started their present job. Therefore, railroad work likely contributes to many of the cases of back pain (Landsbergis et al., 2019).

Half of all working Americans report having back pain symptoms each year. (Vallfors, 1985) At any given time, 31 million people experience lower back pain – or 12.4 percent of the adult population of 249 million people. (American Chiropractic Assn, n.d.) It is estimated that lower back pain is 2.4 times to 5.1 times more prevalent in those who experience frequent lifting and lowering, bending, twisting, and vibration (Van Dieen, 2014) – certainly a characteristic of maintenance-of-way work. This suggests that the 12.4 percent in the general public balloons to at least 29.8 percent to 63.4 percent for maintenance-of-way workers (probably conservative because the intensity of the lifting and lowering, bending, twisting, and vibration characteristic of maintenance-of-way work). Not counting retirees, who, if injured, may seek medical treatment for their backs for their entire lives, the above percentages would suggest that 10,430 to 22,190 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.

While OSHA (OSHA, n.d.) 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 because back problems are the number one reason people miss work (Chandwani, 2013), 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 live with daily. The calculations for this paper are even more conservative. Retirees, who suffer many back problems are not counted nor are those who do maintenance-of-way work but are not BMWED members.

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 8,750 excess back issues. ($35,000 \times 0.5 = 17,500$ expected from general pop. rate; $35,000 \times 0.75$ in rail population = 26,250. Excess= 8,750.) 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 fare \$568.8 million (and this is probably conservative because, over the course of a career, a maintenance-of-way worker could have more than one back problem.

At an estimated average of \$130,000 per case, if there are currently 4,375 excess cases, the cost of back problems to the BMWED community is estimated to be \$568.8 million. The sales needed in the railroad industry to pay for these costs, at 20 percent to 30 percent profit margin, are from \$315,000 to \$533,000 per case, with needed "make-up" sales 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 the railroads 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; and all the relationships and sex life problems associated with two-thirds of all those with back problems. It does not include the pain and suffering for 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 1)

Conclusions

Lower back pain is extremely widespread and costly to the individual, the workplace, the medical 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 suffer.

Acknowledgments

Thanks to Brotherhood of Maintenance of Way Employees Division (BMWED) of the International Brotherhood of Teamsters for its support of this project, especially Rick Inclima, now retired BMWED Director of Safety and Education and current director Roy Morrison. Thanks to the skilled academic team that worked on and helped author this report – Dr. Katherine Mason, Dr. Estye Fenton, Karen Lane, Maria Obando, and Eli Fenton. Thanks to the thousands of BMWED members, current and retired, who responded to the survey as well as those who participated in interviews or were members of focus groups.

REFERENCES

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

- 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, *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.
- Chandwani, H.S. 2016. "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.
- Costa, L., et al. 2012. "The prognosis of acute and persistent low-back pain: a meta-analysis," *CMAJ*, 184(11): E613–E624, August 7, doi:10.1503/cmaj.111271. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3414626/>, accessed November 8, 2016.
- Ganasegeran, K., Perianayagam, W., Nagaraj, P., Al-Dubai, S.A.R. 2014. "Psycho-behavioural risks of low back pain in railway workers," *Occupational Medicine*, 64, doi:10.1093/occmed/kqu039, pp. 372–375 February 2016.
- Gaskin, D. J. and Richard, P. 2016. "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.
- Hoy, D., March, L., Brooks, P., et al. 2014. "The global burden of low back pain: estimates from the Global Burden of Disease 2010 study," *Ann Rheum Dis.*, 73:968–974.
- Jinnett, K. et al., 2016. "Chronic Conditions, Workplace Safety, and Job Demands Contribute to Absenteeism and Job Performance," *Health Affairs*, 36, No 2, doi: 10.1377/hlthaff.1151, pp. 237-244.
- Johanning, E., Landsbergis, P., Fischer, S., Lührman, R. 2004. "Back disorder and ergonomic survey among North American railroad engineers," *J Transport Res Board*, 1899, pp. 145–155, <http://trjournalonline.trb.org/doi/abs/10.3141/1899-19?journalCode=trr>, accessed November 13, 2016.
- Kovacs, F.M., Abreira, V., Zamora, J., Fernández, C. 2005. "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, <https://www.ncbi.nlm.nih.gov/pubmed/16094282>.
- Landsbergis, P., Johanning, E., Stillo, M., Jain, R., Davis, M. 2019. "Work Exposures and Musculoskeletal Disorders Among Railroad Maintenance-of-Way Workers," *JOEM*, Volume 61, Number 7, July.
- Mathew, J., Singh, S., Garis, S., Diwan, A. 2016. "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.
- Miedema, H.S. 2016. "Prognosis and management of nonspecific musculoskeletal disorders," PhD thesis Erasmus University Medical Center Rotterdam.
- Ricci J.A., Stewart, W.F., Chee E., Leotta, C.,Foley, K., Hochberg, M.C. 2006. "Back pain exacerbations and lost

- productive time costs in United States workers," *Spine*, 15;31(26), December.
- Stewart, W.F. et al. 2003. "Lost Productive Time and Cost Due to Common Pain Conditions in the US Workforce," *JAMA*, 290(18), pp. 2443-2454, doi:10.1001/jama.290.18.2443.
- 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 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 Labor, Occupational Safety and Health Administration, "OSHA's Safety Pays Program," <https://www.osha.gov/dcsp/smallbusiness/safetypays/estimator.html>, accessed March 16, 2017.
- Van Dieën, J. 2014. "Low-back pain, a consequence of cumulative mechanical loading?" May 23, <http://www.bodyinmind.org/low-back-pain-and-mechanical-loading/>, accessed November 9, 2016.
- Van Zante-de Fokkert, J. et al. 2007. "The Netherlands Schedules Track Maintenance to Improve Track Workers' Safety," *Interfaces*, Vol 37, No 2, March-April.
- Virtanen, I.M. et al. 2007. "Occupational and Genetic Risk Factors Associated with Intervertebral Disc Disease," *Spine* 32(10).
- Wang, P. et al. 2003. "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.
