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COMPENSATION

Whiplash and the Compensation Hypothesis

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Study Design. Review article.

Objective. To explain why the evidence that compensation-related factors lead to worse health outcomes is not compelling, either in general, or in the specific case of whiplash.

Summary of Background Data. There is a common view that compensation-related factors lead to worse health outcomes ("the compensation hypothesis"), despite the presence of important, and unresolved sources of bias. The empirical evidence on this question has ramifications for the design of compensation schemes.

Methods. Using studies on whiplash, this article outlines the methodological problems that impede attempts to confirm or refute the compensation hypothesis.

Results. Compensation studies are prone to measurement bias, reverse causation bias, and selection bias. Errors in measurement are largely due to the latent nature of whiplash injuries and health itself, a lack of clarity over the unit of measurement (specific factors, or "compensation"), and a lack of appreciation for the heterogeneous qualities of compensation-related factors and schemes. There has been a failure to acknowledge and empirically address reverse causation bias, or the likelihood that poor health influences the decision to pursue compensation: it is unclear if compensation is a cause or a consequence of poor health, or both. Finally, unresolved selection bias (and hence, confounding) is evident in longitudinal studies and natural experiments. In both cases, between-group differences have not been addressed convincingly.

Conclusion. The nature of the relationship between compensation-related factors and health is unclear. Current approaches to testing the compensation hypothesis are prone to several important sources of bias, which compromise the validity of their results. Methods that explicitly test the hypothesis and establish whether or not a causal relationship exists between compensation factors and prolonged whiplash symptoms are needed in future studies.

Key words: causation, compensation, correlation, health outcomes, insurance, self-reported health, whiplash. **Spine 2011;36:S303–S308**

Negative associations between compensation-related factors and persistent symptoms after whiplash[1–3] are often interpreted as evidence that compensation adversely affects health. Some believe the evidence is sufficiently compelling to accept that compensation-related factors are a *cause* of worse health.[4] For convenience, we refer to this idea that a causal pathway runs from compensation factors to worse health as "the compensation hypothesis." Despite its apparent acceptance,[5–8] and indeed its use, in a general sense, to influence injury compensation legislation,[9] serious methodological problems constrain the validity of the compensation hypothesis, regardless of the type of compensable injury.

There are two primary reasons why some characteristics of compensation systems and compensation payments are believed to be harmful to health. First, compensation systems that require individuals to prove their ill-health and functional limitations in an adversarial environment are thought to adversely affect recovery,[10] a view supported by studies showing negative associations between lawyer involvement,[2,3] claiming,[1] and fault-based compensation schemes[11] and health outcomes. Second, the prospect of financial gain is believed to motivate some individuals to exaggerate their injury or their symptoms.[12] This idea that whiplash is a behavioral response to the availability of compensation,[13] which may be supported by third parties also seeking to gain financially,[14] is reinforced by the relative dearth of whiplash in countries where compensation is not available,[15] and by the reduction in the rate of whiplash claims when financial compensation is lowered.[8]

In spite of the apparent support for the compensation hypothesis in relation to whiplash, and there is evidence to the contrary,[16–18] studies to date are subject to flaws which unacceptably heighten the risk of spurious empirical results, irrespective of the conclusions drawn. Some of these

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sources of bias, measurement bias and selection bias, are well-documented in reviews of the whiplash literature.[19–21] However, another important source of bias, reverse causality, or the question of whether compensation is a cause or a consequence of poor health, or both, is only rarely discussed[22,23] in whiplash studies, and has not been addressed empirically in compensation research. Reverse causation bias has serious implications for policy decisions related to compensation scheme design, and, of course, for those affected by such decisions. Policies based on studies which have failed to consider the inverse (and equally plausible) proposition that worse health prompts individuals to seek compensation[24–26] are likely to be ineffective and may inadvertently compromise the health and well-being of those individuals who are in most need of financial assistance.

Using studies on whiplash, this article describes the methodological problems confronting studies on the compensation hypothesis, and discusses them in relation to current empirical approaches. While examples of studies are provided, this article does not constitute a systematic review.

METHODOLOGICAL ISSUES

In the context of compensation research, it is generally not feasible to randomly allocate the treatment of interest, compensation *per se* and/or its related processes (hereafter, compensation-related factors) in an experimental setting. Instead, observational research is relied upon to answer questions about the impact of compensation factors on health. Observational studies are, however, subject to several important sources of bias, and whiplash studies are no exception.[19–21] Testing whether compensation-related factors affect health is complicated by: the difficulties in measuring the concepts of interest (health and compensation), the possibility that the relationship between compensation factors and health is simultaneously and jointly determined (reverse causation bias), and the problem of selection bias, which will confound the association between the variables of interest if it is left unresolved.

Measurement Bias

Measuring Health Status

Health—defined according to the WHO[27] definition—is a latent variable. It cannot be observed directly, and although some indicators of it are observed, it is not possible to actually measure health or ill health, *per se*. Whiplash is, by and large, a latent injury, as there are no objectively discernible features in the vast majority of cases: cervical fractures occur only rarely, and the most common symptom of whiplash is pain, a subjective indicator assumed to be related to soft tissue injury.[6] Self-reported pain, disability, psychosocial and functional status are commonly relied upon as measures of the health status of people with whiplash.[28] Other measures, such as claim duration and return to work, are sometimes used as proxies for health, recovery, or both. These proxies are appealing because they are observed directly and data are relatively easy to collect; however, they do not necessarily coincide with the cessation of symptoms.[6,29–31] There is no consensus as to what constitutes whiplash "recovery."[32]

In compensable environments, the relationship of whiplash symptoms to the true but latent health state is usually unobservable or imperfectly observable, resulting in the potential for moral hazard (*ex post*)[33,34] under such circumstances. Quantifying the presence or extent of this source of measurement error is not currently possible. Although insurers estimate that 5% of whiplash claims are fraudulent,[35] there is no empirical evidence to support this approximation as there is no validated, objective test for identifying whiplash injuries.[36] In addition, studies on people with objectively measurable compensable injuries,[37,38] which, it is argued,[4] are less prone to measurement error from moral hazard, are subject to the same problems arising from unresolved reverse causality and selection bias, discussed below. The reliance on self-reported diagnosis has led to speculation that whiplash is a mythical injury.[13]

Measuring Compensation-Related Variables

Compensation, when defined as a payment from one party to another as recompense for losses arising from an injury, is monetized and hence objectively measurable. However, in the applied work, it is sometimes unclear if the effect of financial compensation *per se* on health is actually of interest, or whether it is the compensation-related processes that are suspected of influencing health. For example, whether or not an individual submits a claim for compensation,[1,17] whether or not a lawyer is retained,[2,3,30] and whether or not litigation is involved[39] are several examples of the measures—all of which represent different phenomena—that have been used to examine the relationship between compensation factors and health in subjects reporting whiplash. This raises the question of whether indicators of these phenomena are meant to reflect otherwise-latent factors that are involved in the compensation-seeking process, or whether they are actually direct measures of the variables of interest.

The foregoing conceptual issue also matters for practical reasons. First, if one suspects that a particular aspect of the compensation-seeking process—for example, lawyer involvement—is a cause of poorer health outcomes, lawyer involvement is the measure of "compensation" that is of direct interest. Conversely, if this variable was chosen as an indicator that compensation was sought, the implications for measurement error are different: individuals who sought compensation but did not retain a lawyer will be misclassified. Second, if particular characteristics of compensation schemes, other than the magnitude of damages sought/awarded, do lead to poorer health outcomes, policies that are designed to curtail compensation payments may not only have zero effect on health outcomes, but may also leave injured people worse off financially.[40]

Finally, injury compensation schemes are commonly quite complex and their designs often differ considerably by jurisdiction and according to the cause of an injury and who was at fault. The array of legal processes and incentives to claim limits the validity of efforts to compare the health of individuals exposed to different schemes.[40] Moreover, the methods for determining eligibility for whiplash compensation differ across countries.[41] Furthermore, classifying individuals according to whether or not they are compensable, whether or not they have sought compensation, or whether or not compensation has been received implies different conceptualizations of the treatment, "compensation." These subtle but important distinctions are often not made.[42]

Reverse Causation Bias

In addition to the potential for measurement error, a source of bias that is less commonly considered but of particular importance in compensation research, is the problem of reverse causality, which refers to the presence of a circular or two-way causal relationship.[43] According to the adage "association is not causation", the presence of a statistical association alone is not sufficient for the purposes of drawing conclusions about the nature of a relationship between two variables; a plausible causal framework is also needed.[44] Where such a framework exists, the interpretation of a statistical association is straightforward. For example, a negative association between age and neck pain is easily interpreted to indicate that a causal pathway runs from age to neck pain because we know that the inverse proposition, neck pain leads to age, is implausible: the causal pathway in this example is unambiguous.

Associations between compensation-related variables and health status are, however, less amenable to interpretation because the causal pathway in the relationship is ambiguous: it is likely to run in both directions. For example, a negative association between claiming compensation and health, which is often interpreted as evidence that claiming leads to worse health, could equally be interpreted as evidence that (worse) health leads to the decision to claim compensation—and the evidence shows that individuals in comparatively worse health are more likely to pursue compensation.[24–26] In short, compensation may affect health, and similarly, health may affect (the decision to pursue) compensation. Both possibilities must be considered to expose the true nature of the relationship between the variables, and these are expressed mathematically in the following two-equation model:

$$HS = f(COMP + X + \mu) \qquad (1)$$

$$COMP = f(HS + Y + \varepsilon) \qquad (2)$$

Equation (1) represents what could be considered the usual approach to testing the effect of compensation-related factors on health, where health status (HS) is a function of compensation-related factors (COMP), contingent on the effects of observed (X) and unobserved (μ) variables, and, equation (2) represents the inverse of (1), which is that exposure to compensation-related factors is a function of health status, contingent on other observed (Y) and unobserved (ε) factors.

Reverse causality is critical to resolve to avoid biased and inconsistent estimates,[45] and this is true regardless of the type of injury and whether or not it is objectively verifiable. Where it is ignored, it will be unclear whether a negative association does indeed reflect a compensation-related effect, or whether it reflects the pursuit of compensation by those with (comparatively) worse health. While the former explanation is often assumed,[4] if the latter were true, policy decisions aimed at reducing compensation benefits could adversely affect those who are in most need of financial assistance.

Reverse causality is not a new concept in compensation research,[46,47] yet, although it is occasionally acknowledged,[22,23] no attempt has been made to resolve it. Additional statistical techniques are required to interpret the direction and the magnitude of an observed association when the potential for an inverse causal relationship is thought to exist. Importantly, bias from reverse causality is systematic and cannot, therefore, be resolved by increasing the number of observations. Possible options to address reverse causation bias include using a two-equation regression model,[45] the use of instrumental variables techniques,[45,48] and fixed and random effects models in longitudinal settings.[45] While a discussion of tests for reverse causation bias and possible methods for addressing it[45,48] is beyond the scope of this article, more attention to this seldom-considered source of bias is needed.

Selection Bias

In addition to the potential for measurement error and reverse causation bias, the problem of selection bias in observational studies involving between-group comparisons must be considered. In particular, when group membership is self-selected, as it is when a decision is made to claim compensation or not, the distribution of characteristics (measured and unmeasured) will differ systematically between the comparator groups; therefore, the health outcomes of claimants and nonclaimants will vary for reasons other than whether or not they made a compensation claim. Selection bias is a well-recognized problem in nonrandomized studies, including those involving whiplash.[19–21] It can result in confounding if between-group differences are not addressed,[49,50] producing results that are spurious and misleading.

When random allocation is infeasible, matching, restricting, or stratifying subjects on the basis of known or suspected confounders,[50] multivariate regression analysis,[50] and propensity score analysis[51] can be used to control for measured (observed) confounders. Unmeasured confounders can be addressed using instrumental variables techniques and, in longitudinal designs, fixed effects models are also an option.[45]

Unless measures are taken to balance the distribution of characteristics among the comparator groups, it will not be possible to determine, reliably, whether or not differences in health outcomes are due to compensation, or due to a third variable (confounder) that also affects health.[50]

EMPIRICAL APPROACHES

Observational data obtained from surveys of individuals presenting for treatment, and from insurance claims databases are used to study the relationship between compensation-related factors and health outcomes after whiplash.

Studies vary widely with respect to their design. Cross-sectional studies have been performed,[52,53] although longitudinal, comparative studies are considered the strongest of the observational designs for drawing causal inferences—notwithstanding the need to address the problems of measurement bias, reverse causality, and selection bias. Quasi-experimental studies have also been undertaken.[8,11]

Among the primary studies, there is variation in sampling procedures and sample characteristics (*e.g.*, place and time of inception, injury severity), study inclusion criteria, outcome measures, compensation-related variables, length and frequency of follow-up, and the covariates included in multivariate analyses. The substantial heterogeneity across compensation studies complicates efforts to conduct meta-analyses, although qualitative syntheses have been undertaken.[6,7,16,18]

Longitudinal Studies

Several longitudinal studies have produced information on the comparative effect on health outcomes of exposure/nonexposure to compensation factors. However, these comparisons are largely incidental, as most such studies are prediction studies[1,3,17,30] that are designed to estimate the probability of an outcome, not to establish whether a causal association exists between two variables.[54] As a result, measures to address selection bias, such as establishing the comparability of claimants and nonclaimants at baseline,[50] and adjusting specifically for variables that may confound the observed relationship between compensation claiming and the outcome of interest,[50] for example, are not apparent. By default, however, it could be argued that selection bias and confounding are dealt with to some extent through the use of multivariate statistical adjustment in these studies, even though this is not deliberate and is not the intention in prediction research.[54] The subtle distinctions in the application of multivariate regression techniques are a cause for some concern if readers draw causal interpretations from prediction studies that have included compensation factors as copredictors. However, irrespective of whether prediction or causality is the motivation for these studies and whether selection bias is fully addressed, the observed association between a compensation-related factor and an outcome variable will be biased and inconsistent if reverse causality has not been addressed[45]; hence, caution is also advised when evaluating the results of prediction studies. Importantly, it is clear that causally-oriented studies are needed.

Longitudinal data have also been applied to test whether the prospect of financial gain alters behavior. In these studies, the health of claimants before and after the settlement of their compensation claims is compared to determine whether the removal of the financial incentive for symptom exaggeration leads to a change in self-reported whiplash symptoms.[55,56] Such an approach arguably deals with selection bias, as individuals serve as their own matched controls, although the potential for moral hazard and reverse causation bias is not obviated by this design.

Natural Experiments

Insurance claims data have been used to examine the effects of changes to compensation scheme design using an approach similar to that of quasi- or "natural" experimental studies. Natural experiments arise when the allocation of the treatment of interest (*e.g.*, compensation *per se* or a compensation-related process) is changed, but when other variables that could affect the relationship of interest remain stable.[48] For such a design to be compelling—for it to enable one to draw a causal interpretation between a treatment and outcome of interest—it must result in an as-good-as-random allocation of the treatment across individuals.

A natural experiment to test the compensation hypothesis would result in the intervention and the control groups being identical except for the compensation-related variable(s) of interest, such as the quantum of compensation, for example. If the groups that are exposed to different compensation treatments are not otherwise identical, the natural experiment design fails due to unresolved selection bias, and hence, the effect is spurious.

Some whiplash studies have employed a natural experiment-like design to test the effects of changes to compensation scheme design on recovery. One such study[8] examines the effect on the rate and duration of claims of changing from a fault-based compensation system to a no-fault system, and another[11] examines the effect on health outcomes of a suite of changes within a fault-based system. Whether or not these policy changes created as-good-as-random allocations of the compensation treatment is questionable, as the observed and unobserved characteristics of the individuals self-selecting to the claimant pool are likely to change when the incentives to claim are altered. If this happens, the natural experiment design becomes less convincing as there are likely to be systematic differences between the pre- and post-change claimant groups, other than those observed. One may, however, argue that selection bias will work to attenuate any observed effect rather than inflate it, as the post-change claimant pool is likely to contain fewer individuals in total.[11] If such an argument is compelling and one still finds an association, the effect, *ceteris paribus*, may be to confirm the qualitative result albeit with a quantitative underestimate of the causal effect. These phenomena have not been tested for in studies to date. Of note here also, as illustrated in the study by Cameron,[11] is the difficulty in measuring the effects of discrete compensation-related factors when packages of legislative changes are introduced.

Systematic Reviews

Three systematic reviews addressing the association between compensation and health in whiplash studies[6,7,16] have yielded conflicting results due to differences in study selection criteria (and in particular, the choice of outcome measure), approaches to quality appraisal, and the method of synthesis. None of the reviews is specifically focused on compensation-related factors. An evaluation of the quality of systematic reviews (including the three whiplash reviews) on compensation-related factors and health outcomes[18] concluded, controversially,[57,58] that there is no high-quality evidence in support of the compensation hypothesis in existing systematic reviews.

DISCUSSION/CONCLUSIONS

This article describes the methodological issues in compensation research, namely, measurement bias, reverse causation bias, and selection bias, which have frustrated efforts to determine whether a causal association exists between compensation-related factors and health. While checklists of causal criteria[59] are sometimes applied in this pursuit, they are thought to over-simplify the process of distinguishing causal associations: an empirically-based approach is more robust.[60] In the social sciences, empirical solutions to the problem of inferring causality from observational data include the exploitation of natural experiments, as described earlier, and/or the use of econometric techniques.[45,48] The objective of these approaches is to account for the problem of reverse causality, and to rule out the possibility that the problems of observational data (*viz*, selection bias and measurement error) are driving an observed association between two variables.

Different approaches to overcoming the methodological problems inherent in compensation research must be considered, regardless of the lack of a common language[61] and of common tools for establishing causality.[44] The need for high quality evidence about the health effects of compensation-related factors is reinforced by the potentially modifiable nature of compensation schemes: if studies are able to confirm or refute the compensation hypothesis, scheme design can be altered accordingly to positively influence (or to avoid negatively influencing) the trajectory of recovery from compensable injuries such as whiplash.

➢ Key Points

- ❑ There is a prevailing view that compensation-related factors lead to worse health outcomes after whiplash; however, important sources of bias are present which hinder the interpretation of the results of existing studies.
- ❑ Causal interpretations of negative associations between compensation and health outcomes are unjustified unless the possibility that health could influence decisions about compensation is satisfactorily addressed.
- ❑ It is important to raise awareness of the limitations of current research on the compensation hypothesis and to apply techniques that will resolve the major sources of bias in future studies.

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References

1. Pobereskin LH. Whiplash following rear end collisions: a prospective cohort study. *J Neurol Neurosurg Psych* 2005;76:1146–51.
2. Dufton JA, Kopec JA, Wong H, et al. Prognostic factors associated with minimal improvement following acute whiplash-associated disorders. *Spine* 2006;31:E759–65.
3. Gun RT, Osti OL, O'Riordan A, et al. Risk factors for prolonged disability after whiplash injury: a prospective study. *Spine* 2005;30:386–91.
4. Cameron P, Gabbe B. The effect of compensation claims on outcomes after injury. *Injury* 2009;40:905–6.
5. Australasian Faculty of Occupational Medicine. *Compensable Injuries and Health Outcomes*. Sydney, Australia: Royal Australasian College of Physicians; 2001.
6. Carroll L, Holm L, Hogg-Johnson S, et al. Course and prognostic factors for neck pain in whiplash-associated disorders (WAD): results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *Spine* 2008;33: 83–92.
7. Côté P, Cassidy JD, Carroll L, et al. A systematic review of the prognosis of acute whiplash and a new conceptual framework to synthesize the literature. *Spine* 2001;26:445–58.
8. Cassidy JD, Carroll L, Côté P, et al. Effect of eliminating compensation for pain and suffering on the outcome of insurance claims for whiplash injury. *N Engl J Med* 2000;342:1179–86.
9. New South Wales Parliament. Legislative Council. General Purpose Standing Committee No. 1: Inquiry into personal injury compensation law. Report 28. 2005. http://www.parliament.nsw.gov.au/prod/parlment/committee.nsf/0/6DEB694C553E0DB8CA2570D100000C9A. Accessed October 19, 2011.
10. O'Donnell C. Motor accident and workers' compensation insurance design for high quality health outcomes and cost containment. *Disabil Rehabil* 2000;22:88–96.
11. Cameron ID, Rebbeck T, Sindhusake D, et al. Legislative change is associated with improved health status in people with whiplash. *Spine* 2008;33:250–4.
12. Ferrari R, Kwan O, Russell AS, et al. The best approach to the problem of whiplash? One ticket to Lithuania, please. *Clin Exp Rheumatol* 1999;17:321–26.
13. Ferrari R. Myths of whiplash. *Surgeon* 2003;1:99,101–3.
14. Kwan O, Ferrari R, Friel J. Tertiary gain and disability syndromes. *Med Hypotheses* 2001;56:77–84.
15. Schrader H, Obelieniene D, Bovim G, et al. Natural evolution of late whiplash syndrome outside the medicolegal context. *Lancet* 1996;347:1207–11.
16. Scholten-Peeters G, Verhagen A, Bekkering G, et al. Prognostic factors of whiplash-associated disorders: a systematic review of prospective cohort studies. *Pain* 2003;104:303–22.
17. Sterling M, Jull G, Kenardy J. Physical and psychological factors maintain long-term predictive capacity post-whiplash injury. *Pain* 2006;122:102–8.
18. Spearing NM, Connelly LB. Is compensation bad for health? A systematic meta-review. *Injury* 2011;42:15–24.
19. Kwan O, Friel J. A review and methodologic critique of the literature supporting 'chronic whiplash injury': part I–research articles. *Med Sci Monit* 2003;9:RA203–15.
20. Freeman MD, Croft AC, Rossignol AM, et al. A review and methodologic critique of the literature refuting whiplash syndrome. *Spine* 1999;24:86–96.
21. Carroll LJ, Hurwitz EL, Côté P, et al. Research priorities and methodological implications: the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *J Manipulative Physiol Ther* 2009;32:S244–51.
22. Atherton K, Wiles NJ, Lecky FE, et al. Predictors of persistent neck pain after whiplash injury. *Emerg Med J* 2006;23:195–201.
23. Joslin CC, Khan SN, Bannister GC. Long-term disability after neck injury. A comparative study. *J Bone Joint Surg (Br)* 2004;86: 1032–34.
24. Elliott J, Sterling M, Noteboom JT, et al. The clinical presentation of chronic whiplash and the relationship to findings of MRI fatty infiltrates in the cervical extensor musculature: a preliminary investigation. *Eur Spine J* 2009;18:1371–8.
25. Gargan MF, Bannister GC. The rate of recovery following whiplash injury. *Eur Spine J* 1994;3:162–4.
26. Norris SH, Watt I. The prognosis of neck injuries resulting from rear-end vehicle collisions. *J Bone Joint Surg Br* 1983;65: 608–11.
27. World Health Organization. Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948. http://www.who.int/governance/eb/who_constitution_en.pdf. Accessed October 19, 2011.
28. Nordin M, Carragee EJ, Hogg-Johnson S, et al. Assessment of neck pain and its associated disorders: results of the Bone and Joint

Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *Spine* 2008;33:S101–22.
29. Brison RJ, Hartling L, Pickett W. Prospective study of acceleration-extension injuries following rear-end motor vehicle collisions. *J Musculoskelet Pain* 2000;8:97–113.
30. Hendriks EJ, Scholten-Peeters GG, van der Windt DA, et al. Prognostic factors for poor recovery in acute whiplash patients. *Pain* 2005;114:408–16.
31. Rebbeck T, Sindhusake D, Cameron I, et al. A prospective cohort study of health outcomes following whiplash associated disorders in an Australian population. *Inj Prev* 2006;12:93–8.
32. Walton D. A review of the definitions of 'recovery' used in prognostic studies on whiplash using an ICF framework. *Disabil Rehabil* 2009;31:943–57.
33. Arrow KJ. Uncertainty and the welfare economics of medical care. *Am Econ Rev* 1963;LIII:941–73.
34. Pauly MV. The economics of moral hazard: comment. *Am Econ Rev* 1968;58:531–7.
35. Association of British Insurers. Tackling whiplash, prevention, care, compensation. 2008. http://www.abi.org.uk/Publications/Tackling_Whiplash_Prevention_Care_Compensation1.aspx. Accessed July 25, 2011.
36. Elliott J, Noteboom JT, Flynn TW, et al. Characterization of acute and chronic whiplash-associated disorders. *J Orthop Sports Phys Ther* 2009;39:312–23.
37. Gabbe BJ, Cameron PA, Williamson OD, et al. The relationship between compensable status and long-term patient outcomes following orthopaedic trauma. *Med J Aust* 2007;187:14–7.
38. O'Donnell M, Creamer M, McFarlane A, et al. Does access to compensation have an impact on recovery outcomes after injury? *Med J Aust* 2010;192:328–33.
39. Kasch H, Bach FW, Jensen TS. Handicap after acute whiplash injury: a 1-year prospective study of risk factors. *Neurology* 2001;56:1637–43.
40. Connelly LB, Spearing N. Compensation and health outcomes. In: Sterling M, Kenardy J, eds. *Whiplash: Evidence Base for Clinical Practice*. Chatswood, Australia: Churchill Livingstone; 2011: 144–56.
41. Chappuis G, Soltermann B. Number and cost of claims linked to minor cervical trauma in Europe: results from the comparative study by CEA, AREDOC and CEREDOC. *Eur Spine J* 2008;17:1350–7.
42. Grant G, Studdert DM. Poisoned chalice? A critical analysis of the association between personal injury compensation processes and adverse health outcomes. University of Melbourne Legal Studies Research Paper No. 442. 2009. http://ssrn.com/abstract = 1520788. Accessed October 15, 2010.
43. Culyer AJ. *The Dictionary of Health Economics*. 2nd ed. Cheltenham, United Kingdom: Edward Elgar; 2010.
44. Pearl J. *Causality: Models, Reasoning, and Inference*. 2nd ed. New York, NY: Cambridge University Press; 2009.
45. Wooldridge JM. *Introductory Econometrics: A Modern Approach*. 4th ed. Mason, OH: South-Western Cengage Learning; 2009.
46. Dworkin RH. Compensation in chronic pain patients: cause or consequence? *Pain* 1990;43:387–8.
47. Teasell RW. Compensation and chronic pain. *Clin J Pain* 2001;17:S46–51.
48. Angrist JD, Pischke JS. *Mostly Harmless Econometrics*. Princeton, NJ: Princeton University Press; 2009.
49. Rochon P, Gurwitz J, Sykora K, et al. Reader's guide to critical appraisal of cohort studies: 1. Role and design. *BMJ* 2005;330: 895–7.
50. Grimes D, Schulz K. Bias and causal associations in observational research. *Lancet* 2002;359:248–52.
51. Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. *Biometrika* 1983;709: 41–55.
52. Klein GN, Mannion AF, Panjabi MM, et al. Trapped in the neutral zone: another symptom of whiplash-associated disorder? *Eur Spine J* 2001;10:141–8.
53. Swartzman LC, Teasell RW, Shapiro AP, et al. The effect of litigation status on adjustment to whiplash injury. *Spine* 1996;21: 53–8.
54. Moons KG, Royston P, Vergouwe Y, et al. Prognosis and prognostic research: what, why and how? *BMJ* 2009;338: b375.
55. Maimaris C, Barnes MR, Allen MJ. Whiplash injuries of the neck: a retrospective study. *Injury* 1988;19:393–96.
56. Sapir D, Gorup J. Radiofrequency medial branch neurotomy in litigant and nonlitigant patients with cervical whiplash: a prospective study. *Spine* 2001;26:E268–73.
57. Spearing NM, Connelly LB. Response to Cassidy JD, et al. *Injury* 2011;42:429–30.
58. Cassidy JD, Bendix T, Rasmussen C, et al. Re: Spearing and Connelly. Is compensation bad for health? A systematic meta-review. Injury 2011;42:15–24. *Injury* 2011;42:428–9.
59. Hill AB. The environment and disease: association or causation? *Proc R Soc Med* 1965;58:295–300.
60. Rothman KJ, Greenland S. Causation and causal inference in epidemiology. *Am J Public Health* 2005;95:S144–50.
61. Gunasekara FI, Carter K, Blakely T. Glossary for econometrics and epidemiology. *J Epidemiol Community Health* 2008;62: 858–61.