

Comment on
Brian Martin's article "Bad social science"

For *Social Epistemology Review and Reply Collective*

Alan Sokal

*Department of Mathematics
University College London*

and

*Department of Physics
New York University*

E-mail: SOKAL@NYU.EDU

May 13, 2019

I am very sympathetic to Professor Martin's central thesis: that much social and political commentary — by citizens, journalists and even academics — makes

claims about society and social relationships that fall very far short of what social scientists consider good scholarship. This might be due to using false or misleading evidence, making faulty arguments, drawing unsupported conclusions or various other severe methodological, empirical or theoretical deficiencies.

I also agree that

there is value in a more systematic examination of different sorts of everyday bad social science. Such an examination can point to what is important in doing *good* social science and to weaknesses in assumptions, evidence and argumentation. It can also provide insights into how to defend and promote high-quality social analysis.

And finally, I agree completely that *ad hominem* argument is ethically reprehensible and intellectually vacuous, as is the misrepresentation of an opponent's claims or arguments; and that ambiguous terminology, failing to summarize clearly an opponent's main arguments, and criticizing an opponent's weakest arguments while ignoring the strongest ones are also logically and ethically deficient strategies (though these sins are perhaps slightly less iniquitous than *ad hominem* and misrepresentation).

I also endorse Martin's suggestion that one should verify claims — particularly derogatory claims about opponents — with the people involved, and more generally that it can be useful to send drafts of articles to people with opposing views, soliciting their comments and suggestions prior to publication. Indeed, I can personally testify that Martin practices what he preaches; and I beg the reader's indulgence to tell this story in a bit of detail, because I think it illustrates well why Martin's suggestion is so valuable.

Back in January 2019, Professor Martin sent me a draft of his almost-completed article, saying:

Attached is a draft article, "Bad social science". In it, I discuss your hoax [Sokal 1996]. Could you have a look at the relevant subsection . . . and let me know about any inaccuracies or omissions? Comments on any other part of the article would be welcome too.

After reading his draft, I replied:

I want first to say "thank you" once again for sending this draft to me for my comments prior to publishing it . . . For indeed, I believe that you have seriously misrepresented my views.

And I went on to explain:

The first sentence [of the section discussing my hoax] is fine. You then say: "He [Sokal] concluded from this episode that cultural studies as a field lacked rigour and quality control." But where is the precise citation to back up such a claim? Your footnote 24 [deleted from the final version] cites a 465-page

book [Sokal 2008], but without any citation of page numbers, much less precise quotations. (I am always irritated by such vague citations, which are useless to the reader — but actually *worse* than useless because they give the *impression* of documentation without the reality of it.) In fact, I don't know *anywhere* in my writings where you could find a quotation asserting what you have written, because it is not at all my view. Indeed, I have many times explicitly written the exact opposite!

After which I quoted at length from an article I wrote about a year after the hoax, which reads in part:

From the mere fact of publication of my parody I think that not much can be deduced. It doesn't prove that the whole field of cultural studies, or cultural studies of science — much less sociology of science — is nonsense. Nor does it prove that the intellectual standards in these fields are generally lax. (This might be the case, but it would have to be established on other grounds.) ...¹

Professor Martin immediately responded to thank me for “sav[ing] [him] from making some unfortunate mistakes”, and two weeks later he sent me a revised version of his article for my comment; I found its account of my views completely acceptable, and it is the version that is published here.

Let me also stress that Martin did not take the easy way out: making the minimum changes to his text to avoid stating an outright falsehood, while nevertheless holding onto the essence of his conclusion. Rather, he did the intellectually honorable thing: completely revising his conclusion in light of the new evidence I had given him. And that, indeed, is what is so valuable about sending drafts to people with opposing views: it gives us the opportunity to *change* and *improve* our ideas, via exposure to new evidence and/or persuasive new reasoning.

I do not feel qualified to comment on the details of Martin's analysis of the Australian vaccination debate, with which I am not familiar. However, I can make a few brief comments about his examples:

1) I agree with Martin that it is justified to call someone a “liar” only if one has strong evidence that the person in question is *consciously* intending to deceive. In the type of situation cited by Martin, a more appropriate accusation might be “persisted in making claims that had been refuted by strong evidence, without addressing that evidence”. Of course, as Martin replied to me, participants on different sides of the controversy might well have “different assumptions about what is relevant evidence ... and different assessments of the relevance of evidence”. But these assumptions can and should be made explicit, and these assessments openly debated. If one side (or both sides) in the controversy refuses to do so, then that refusal deserves to be criticized.

2) I also agree with Martin that it is unhelpful to use inflammatory terms such as “babykiller”, even when the implicit factual claim — that discouraging vaccination causes the death of children from vaccination-preventable diseases — is supported

¹Sokal (1998, p. 11).

by evidence. Furthermore, as concerns measles — the disease most at danger of resurgence due to anti-vaccination campaigns — death is fortunately nowadays very rare in the developed countries, occurring in only one or two cases per thousand.² So, despite large-scale outbreaks of measles on a scale not seen in decades — like the one that is occurring in the USA even as I write, with 704 cases thus far, of which 66 hospitalizations³ — there have not yet been any deaths. Consequently, if we were to consider the situation of the USA, Europe or Australia in isolation from the rest of the world, “babykiller” would indeed be a gross exaggeration.

But ideas (such as the alleged dangers of vaccination) are not stopped by national borders; and the nonchalance available to parents in the rich countries does not, alas, extend to the vast majority of humanity. As the Wikipedia article on measles usefully summarizes:

Measles affects about 20 million people a year, primarily in the developing areas of Africa and Asia. . . . It is one of the leading vaccine-preventable disease causes of death. In 1980, 2.6 million people died of it, and in 1990, 545,000 died; by 2014, global vaccination programs had reduced the number of deaths from measles to 73,000. Rates of disease and deaths, however, increased in 2017 to 2019 due to a decrease in immunization. . . . Most of those who die from the infection are less than five years old.

In developed countries, death occurs in one to two cases out of every 1,000 (0.1–0.2%). In populations with high levels of malnutrition and a lack of adequate healthcare, mortality can be as high as 10%. In cases with complications, the rate may rise to 20–30%.⁴

The World Health Organization reports that

A previously described model for estimating measles disease and mortality was updated with new data on measles vaccination coverage and cases . . . During 2000–2017, as compared with no measles vaccination, measles vaccination prevented an estimated 21.1 million deaths globally . . .⁵

So perhaps “babykiller” (or rather, “child-killer”) is not so out of line, after all.

Still, I agree with Martin that when accusations such as “babykiller” are employed *without* citation of evidence to support the implicit factual claim, this constitutes bad social science.

3) With regard to the notorious case of Andrew Wakefield, Martin says that

²Centers for Disease Control and Prevention (2015, p. 211).

³McNeil (2019). See also Bradford and Mandich (2015), Phadke *et al.* (2016), Lo and Hotez (2017) and Bednarczyk *et al.* (2019) for related statistical information concerning the public-health consequences of non-medical exemptions to immunization.

⁴See <http://en.wikipedia.org/wiki/Measles>, where references to the original sources can be found.

⁵World Health Organization (2018, p. 656; see also p. 657, Figure 1 for a graph with error bars). It is only fair to observe that the error bars (95% confidence limits) are fairly large; the actual number of avoided deaths could be as small as 14 million or as large as 28 million.

Incorrect statements about Wakefield are commonplace, for example that he lost his medical licence due to scientific fraud. It is a simple matter to check the facts, but apparently few do this.

So I did check the facts — which is indeed a fairly simple matter, though a bit time-consuming to do properly — and obtained results that are in stark contrast to Martin’s portrayal.

In response to accusations of scientific fraud and other ethical violations in the research reported by Wakefield and his co-authors in the *Lancet* (Wakefield *et al.* 1998) — which purported to find a possible causal link between the measles–mumps–rubella (MMR) vaccination and autism — the General Medical Council (U.K.) conducted an investigation that involved “evidence and submissions for 148 days over a period of two and a half years” followed by 45 days of deliberation *in camera*, and which applied the evidentiary standard of proof “beyond reasonable doubt”.⁶ The GMC report began its analysis of the *Lancet* paper by observing that Wakefield

knew or ought to have known that [his] reporting in the *Lancet* paper of a temporal link between the syndrome [he] described [gastrointestinal disease and developmental regression in a group of previously normal children] and the MMR vaccination,

- i. had major public health implications,
- ii. would attract intense public and media interest,

and that he

- i. knew or ought to have known the importance of accurately and honestly describing the patient population,
- ii. had a duty to ensure that the factual information in the paper and provided by [him] in response to queries about it was true and accurate,
- iii. had a duty to disclose to the Editor of the *Lancet* any disclosable interest including matters which could legitimately give rise to a perception that [he] had a conflict of interest.

The report found that Wakefield’s conduct was “dishonest” and “irresponsible” in all three aspects:

1) The *Lancet* paper — of which Wakefield was the senior author — provided “a misleading description of the patient population” and of the process by which the patients were recruited, implying — albeit without stating explicitly — that

the children who were the subject of the paper . . . [came by] a routine referral to the gastroenterology department in relation to symptoms which included gastrointestinal symptoms [and by] a routine process in which the investigators had played no active part.⁷

⁶That is, all cases in which the Panel felt there existed reasonable doubt were labeled “found not proved” and were considered to be resolved in favor of Dr. Wakefield. General Medical Council (2010a, p. 2).

⁷General Medical Council (2010a, p. 45, item 33).

The GMC found both implied assertions to be false and judged Wakefield’s behavior to be “dishonest”, “irresponsible” and “contrary to your duty to ensure that the information in the paper was accurate”.⁸

2) In response to critics’ worries that there might have been a biased selection of patients, Wakefield responded in the *Lancet* by stating unequivocally that

These children have all been seen expressly on the basis that they were referred through the normal channels (eg, from general practitioner, child psychiatrist, or community paediatrician) on the merits of their symptoms.⁹

The GMC determined that this statement was “dishonest”, “irresponsible” and “contrary to your duty to ensure that the information provided by you was accurate”:

The Panel has found that your statement . . . does not respond fully and accurately to the queries made by correspondents to the *Lancet*. . . [Y]ou knew that this statement omitted necessary and relevant information, such as the active role you played in the referral process, and the fact that the referral letters in four cases made no mention of any gastrointestinal symptoms and the fact that the investigations had been carried out under Project 172-96 for research purposes. Therefore, the Panel is satisfied that your conduct in this regard was dishonest and irresponsible.¹⁰

In response to another correspondent’s suspicion that some of Wakefield’s patients might be connected to the MMR litigation — a potential source of selection bias — Wakefield admitted for the first time that “one author (AJW) has agreed to help evaluate a small number of these children on behalf of the Legal Aid Board” — a vast understatement, as we shall soon see — but insisted categorically that “No conflict of interest exists.” Ironically, Wakefield’s reply began with the correct observation that “Bias occurs in science when data are either wittingly or unwittingly concealed.”¹¹

3) Similarly, a month after the *Lancet* article, at an important scientific meeting at the Medical Research Council

convened to examine the evidence relating to measles or measles vaccine and chronic intestinal inflammation, you were asked about the issue of bias in generating the series of cases including the twelve children in the *Lancet* paper and you stated that all patients reviewed so far had come through General Practitioners or paediatricians by “the standard route”

— a statement that the GMC found once again to be “dishonest”, “irresponsible” and “contrary to your duty to ensure that the information provided by you was accurate”:

The Panel has taken into account that this was an important scientific meeting to consider the implications of your published research and the major

⁸General Medical Council (2010a, pp. 44–46, items 32–34).

⁹Wakefield (1998).

¹⁰General Medical Council (2010a, p. 47, item 35).

¹¹Wakefield (1998).

public health implications arising from it. The Panel has found that your responses to the questions raised at this meeting were inaccurate.

The Panel is satisfied that you knew that your response to the questions was factually wrong. The statement you made would be considered by ordinary standards of reasonable and honest people to be dishonest. The Panel is satisfied that your conduct in this regard was dishonest and irresponsible.¹²

The report also found several undisclosed conflicts of interest:

4) *Involvement in MMR litigation*: Starting in 1996 — two years before the *Lancet* article — Wakefield was

- a. . . . involved in advising Richard Barr, a solicitor acting for persons alleged to have suffered harm caused by the administration of the MMR vaccine, as to the research that would be required to establish that the vaccine was causing injury
- b. Mr Barr had the benefit of public funding from the Legal Aid Board in relation to the pursuit of litigation against manufacturers of the MMR vaccine (“the MMR litigation”)
- c. [Wakefield] provided Mr Barr with,
 - i. costing proposals for a research study . . .
 - ii. a protocol, giving details of the research study . . .
- g. On 22 August 1996 the Legal Aid Board agreed to provide a maximum cost of £55,000 to fund the items in the Costing Proposal . . .
- h. The Legal Aid Board provided funding in two instalments of £25,000, in late 1996 and in 1999 respectively . . .¹³

But that is not all: in December 2006 journalist Brian Deer learned, pursuant to a Freedom of Information Act request, that the Legal Services Commission (formerly Legal Aid Board) had paid Wakefield the staggering sum of £435,643 fees plus £3,910 expenses as an “expert” in the MMR litigation.¹⁴

5) *Patent applications*: On 5 June 1997 — more than eight months *before* the *Lancet* article was published — Wakefield filed a patent application for a new measles vaccine to replace the standard MMR vaccine, asserting that this would avoid the inflammatory bowel disease (IBD) and regressive behavioural disease (RBD, i.e. autism) that is, according to the application, associated with MMR vaccination.¹⁵ A revised application was filed on 4 June 1998, three months after the *Lancet* paper; it stated *inter alia* that

¹²General Medical Council (2010a, pp. 47–48, item 36).

¹³General Medical Council (2010a, pp. 4–6, items 3 and 4).

¹⁴Deer (n.d. #3). For reasons unknown to me, the GMC report does not mention these latter payments.

¹⁵Intellectual Property Office (1997); Deer (n.d. #2); General Medical Council (2010a, p. 49, item 38).

It has now also been shown that use of the MMR vaccine . . . results in ileal lymphoid nodular hyperplasia, chronic colitis and pervasive developmental disorder including autism (RBD), in some infants.¹⁶

— and this despite the unambiguous admission in the *Lancet* paper that

We did not prove an association between measles, mumps and rubella vaccine and the syndrome described.¹⁷

It is telling that at the press conference announcing the *Lancet* article, as well as in many subsequent forums, Wakefield forcefully advocated single measles, mumps and rubella vaccinations, spaced 12 months apart, in place of the combined MMR vaccine.¹⁸

Wakefield’s lucrative involvement in the MMR litigation and his patent application represented glaring conflicts of interest, which he did not disclose to the Editor of the *Lancet* or to the Ethics Committee at the Royal Free Hospital, and which were only revealed publicly many years later, by investigative journalist Brian Deer.¹⁹

In short, items 1–3 above constitute clear instances of scientific fraud²⁰; items 4–5 constitute gross and undisclosed conflicts of interest; and the two transgressions clearly work in tandem.

Finally, the GMC report also found Wakefield guilty of several other ethical violations, including invasive procedures (such as lumbar puncture) on child patients

¹⁶Wakefield and Fundenberg (1998, pp. 1–2). See also similar statements on pp. 3–4. Two years later, Wakefield filed a companion patent application in the USA, with almost identical text. This latter patent was granted in 2003, but — curiously — covering only “a method for the diagnosis of Regressive Behavioral Disease”, not the vaccine (Wakefield 2003). Since the dossier at the U.S. Patent Office website shows a “non-final rejection” on September 28, 2001 and a “final rejection” on July 1, 2002, followed by a final “notice of allowance” on October 22, 2002, my guess — which would require further investigation to check — is that the claims for the vaccine were rejected, but then, after correspondence with Wakefield’s lawyers, revised claims for the diagnosis method were allowed.

¹⁷Wakefield *et al.* (1998, p. 641).

¹⁸Boseley (1998a); Deer (n.d. #1); Bower (1998); Murray (1998a). It should be noted that single vaccinations carry dangers of their own: as Sir Kenneth Calman, U.K. Chief Medical Officer, pointed out, “Giving the vaccinations separately would mean three visits and three injections. For a minimum of two years a child would not be immunised against a disease which could kill or maim. I am not prepared to encourage something which might harm children.” (Murray 1998b; see also Boseley 1998b)

¹⁹General Medical Council (2010a, pp. 7–11, items 5–7 and pp. 49–50, item 39). See also Deer (2012) for an informative chronology.

²⁰The term “scientific fraud” does not appear to have any universally accepted definition, but it is generally understood to mean something like “intentional misrepresentation of the methods, procedures, or results of scientific research” (Katkin 2003, p. 277). The related term “research misconduct” is formally defined by the U.S. government to mean “fabrication, falsification, or plagiarism”, where “falsification” is defined as “manipulating research materials, equipment, or processes, or changing or omitting data or results such that the research is not accurately represented in the research record” (42 CFR 93.103 and 45 CFR 689.1). For what it’s worth, Martin (1992) criticizes this definition of scientific fraud as overly narrow.

that were not clinically indicated.²¹

Four months after this report, the GMC weighed the entire case: it determined that any single one of several proved allegations — most notably the failure to disclose conflicts of interest, and the breach of ethical constraints on research — constituted, in and of itself, Serious Professional Misconduct.²² Combining the many serious violations, the GMC concluded that no sanction short of de-registration would be

sufficient or appropriate against a background of several aggravating factors and in the absence of any mitigating submissions made on [Wakefield’s] behalf. Dr Wakefield’s continued lack of insight as to his misconduct serve [*sic*] only to satisfy the Panel that suspension is not sufficient and that his actions are incompatible with his continued registration as a medical practitioner.²³

In conclusion: it is not quite correct to say that Wakefield lost his medical licence due to scientific fraud. Rather, he lost his medical licence due to a long series of serious ethical transgressions that included, *among other things*, scientific fraud. The scientific fraud seems, in fact, to have loomed smallest in the GMC’s reckoning of Wakefield’s misdeeds²⁴, but in the long run it will surely be the gravest: if the scare that Wakefield started, and that he continues to abet, causes even a 5% increase in measles incidence worldwide²⁵ — an extremely modest scenario — it will be responsible for more than 50,000 avoidable child deaths in the coming decade alone.²⁶

I wish to thank Brian Martin for giving me permission to quote from his now-superseded preliminary draft, as well as for helpful comments on my own draft.

Bibliography

Bednarczyk, Robert A. *et al.* 2019. Current landscape of nonmedical vaccination exemptions in the United States: Impact of policy changes. *Expert Review of Vaccines* 18(2): 175–190.

Boseley, Sarah. 1998a. Alert over child jabs. *The Guardian*, 27 February, p. 1.

²¹General Medical Council (2010a, pp. 11–42, items 8–29 and pp. 50–55, items 40–42). Some of these allegations were “found proved” and others were “found not proved”.

²²Strangely, while the misleading statements in the *Lancet* article and subsequent forums were repeatedly called “dishonest” and “irresponsible”, the GMC final report did not single them out as constituting Serious Professional Misconduct in their own right (General Medical Council 2010b, pp. 4–5). Perhaps this is because the GMC is a *medical* council and is therefore most concerned with *medical* ethics in the narrow sense, i.e. the protection of the welfare of doctors’ patients.

²³General Medical Council (2010b, p. 9).

²⁴See footnote 22 above.

²⁵Compared to what it would have been without the scare.

²⁶This is based on the current (2017) figure of approximately 110,000 measles deaths per year (World Health Organization 2018, p. 656).

Boseley, Sarah. 1998b. MMR vaccination fears ‘not justified’: No evidence of link to autism or bowel disease, scientists say. *The Guardian*, 25 March, p. 3.

Bower, Hilary. 1998. Link with bowel disease fuels controversy over vaccine. *British Medical Journal* **316**: 723 (7 March).

Bradford, W. David and Mandich, Anne. 2015. Some state vaccination laws contribute to greater exemption rates and disease Outbreaks in the United States. *Health Affairs* **34**(8): 1383–1390.

Centers for Disease Control and Prevention. 2015. *Epidemiology and Prevention of Vaccine-Preventable Diseases*, 13th edition. Washington, D.C.: Public Health Foundation. Chapter 13: Measles. Available on-line at <http://www.cdc.gov/vaccines/pubs/pinkbook/meas.html>

Deer, Brian. n.d. #1. Royal Free MMR video news release, 1998. Available on-line at <http://briandeer.com/wakefield/royal-video.htm>

Deer, Brian. n.d. #2. Andrew Wakefield’s vaccine patent. Available on-line at <http://briandeer.com/wakefield/vaccine-patent.htm>

Deer, Brian. n.d. #3. Secret payments to MMR Wakefield. Available on-line at <http://briandeer.com/wakefield/legal-aid.htm>

Deer, Brian. 2012. Amended declaration of Brian Deer in support of defendants’ anti-SLAPP motion to dismiss. In the District Court of Travis County, Texas, 250th Judicial District. Dated 9 July 2012. Available on-line at <http://briandeer.com/solved/slapp-amended-declaration.pdf>

General Medical Council (U.K.). 2010a. Fitness to practise panel hearing, 28 January 2010. Available on-line at <http://briandeer.com/solved/gmc-charge-sheet.pdf>

General Medical Council (U.K.). 2010b. Dr Andrew Jeremy Wakefield, Determination on Serious Professional Misconduct (SPM) and sanction, 24 May 2010. Available on-line at http://web.archive.org/web/20110809092833/http://www.gmc-uk.org/Wakefield_SPM_and_SANCTION.pdf_32595267.pdf

Intellectual Property Office (U.K.). 1997. Pharmaceutical composition for treatment of ibd and rbd. Patent application GB9711663.6, 5 June 1997. Available on-line at <http://www.ipo.gov.uk/p-ipsu/Case/ApplicationNumber/GB9711663.6>

Katkin, Kenneth. 2003. Scientific fraud. In: *Dictionary of American History*, 3rd ed., edited by Stanley I. Kutler, vol. 7, pp. 277–279. New York: Charles Scribner’s Sons. Available on-line at <http://link.galegroup.com/apps/doc/CX3401803766/GVRL?u=new64731&sid=GVRL&xid=a44f927> and <http://www.encyclopedia.com/history/dictionaries-thesauruses-pictures-and-press-releases/scientific-fraud>

Lo, Nathan C. and Hotez, Peter J. 2017. Public health and economic consequences of vaccine hesitancy for measles in the United States. *JAMA Pediatrics* **171**(9): 887–892.

Martin, Brian. 1992. Scientific fraud and the power structure of science. *Prometheus* **10**: 83–98. Available on-line at <http://www.uow.edu.au/~bmartin/pubs/92prom.html>

Martin, Brian. 2019. Bad social science. *Social Epistemology Review and Reply Collective* **8**, no. 3: 6–16. Available on-line at <http://social-epistemology.com/2019/03/05/bad-social-science-brian-martin/>

McNeil, Donald G., Jr. 2019. Measles surges past 700th case in U.S. outbreak. *New York Times*, April 29, page A1. Available on-line at <http://www.nytimes.com/2019/04/29/health/measles-outbreak-cdc.html>

Murray, Ian. 1998a. Health chief defends triple vaccine. *The Times* [London], 13 March, p. 10.

Murray, Ian. 1998b. Triple baby vaccine is safe, experts tell parents. *The Times* [London], 25 March, p. 11.

Phadke, Varun H. *et al.* 2016. Association between vaccine refusal and vaccine-preventable diseases in the United States: A review of measles and pertussis. *Journal of the American Medical Association* **315**(11): 1149–1158.

Sokal, Alan. 1996. Transgressing the boundaries: Towards a transformative hermeneutics of quantum gravity. *Social Text* **#46/47** (Spring/Summer): 217–252. Available on-line at <http://physics.nyu.edu/sokal/#transgress> [Reprinted with annotations in Sokal 2008, chapter 1.]

Sokal, Alan. 1998. What the *Social Text* affair does and does not prove. In: *A House Built on Sand: Exposing Postmodernist Myths about Science*, edited by Noretta Koertge, pp. 9–22. New York–Oxford: Oxford University Press. Available on-line at <http://physics.nyu.edu/sokal/#noretta> [Reprinted in slightly condensed form in Sokal 2008, chapter 5.]

Sokal, Alan. 2008. *Beyond the Hoax: Science, Philosophy and Culture*. Oxford–New York: Oxford University Press.

Wakefield, Andrew. 1998. Author’s reply. *The Lancet* **351**: 1356 (2 May).

Wakefield, Andrew. 2003. Regressive behavioral disorder diagnosis. United States Patent US 6,534,259 B1. Filed March 23, 2000; granted March 18, 2003; normal expiration date June 4, 2018; expired March 18, 2011 due to non-payment of maintenance fees. Available on-line at <http://portal.uspto.gov/pair/PublicPair>

Wakefield, Andrew Jeremy and Fundenberg [*sic*], Hugh. 1998. UK Patent Application GB 2 325 856 A, filed 4 June 1998, published 9 December 1998. Available on-line at <http://briandeer.com/mmr/1998-vaccine-patent.pdf>

Wakefield, A.J., Murch, S.H., Anthony, A. *et al.* 1998. Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children. *The Lancet* **351**: 637–641 (28 February). Retraction: *The Lancet* **375**: 445 (2010).

World Health Organization. 2018. Progress towards regional measles elimination – worldwide, 2000–2017. *Weekly Epidemiological Record* **93**: 649–660 (30 November). Available on-line at <https://www.who.int/wer/2018/wer9348/en/>