

[Heller v. Shaw Indus., Inc.](#)

United States Court of Appeals for the Third Circuit

October 6, 1998, Argued ; February 3, 1999, Filed

NO. 97-1735

Reporter

167 F.3d 146 *; 1999 U.S. App. LEXIS 1426 **; 50 Fed. R. Evid. Serv. (Callaghan) 1393; CCH Prod. Liab. Rep. P15,443; 29 ELR 20532

CAROL HELLER; THOMAS HELLER individually and as the parents and natural guardians of EMILY HELLER and KATHERINE HELLER, minor children, Appellants v. SHAW INDUSTRIES, INC.

Prior History: **[**1]** On Appeal from the United States District Court For the Eastern District of Pennsylvania. (D.C. Civ. No. 97-07657). District Judge: Honorable William H. Yohn, Jr.

Disposition: Affirmed.

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Judges: Before: BECKER, Chief Judge, NYGAARD, and NOONAN, * Circuit Judges.

Opinion by: BECKER

Opinion

[*149] OPINION OF THE COURT

BECKER, *Chief Judge*:

This is an appeal by plaintiff Carol Heller ("Heller"), who sought to recover from defendant Shaw Industries ("Shaw"), for certain respiratory illnesses allegedly caused by volatile organic compounds emitted by Shaw carpet installed in Heller's former home. The District Court's grant of summary judgment against Heller and in favor of Shaw **[**2]** is largely a function of its exclusion, following an extensive in limine hearing, of key expert testimony by which Heller hoped to establish liability. See [Heller v. Shaw Indus., Inc., 1997 U.S. Dist. LEXIS 12399](#), No. Civ.A. 95-7657, 1997 WL 535163 (E.D. Pa. Aug. 18, 1997). In reviewing the District Court's rulings, we revisit the caselaw interpreting [Federal Rule of Evidence 702](#), particularly [Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579, 125 L. Ed. 2d 469, 113 S. Ct. 2786 \(1993\)](#), and [In re Paoli Railroad Yard PCB Litigation, 35 F.3d 717 \(3d Cir. 1994\)](#), and apply their teachings to this case.

After careful but deferential review, see [General Elec. Co. v. Joiner, 522 U.S. 136, 118 S. Ct. 512, 517, 139 L. Ed. 2d 508 \(1997\)](#), we conclude that, although the District Court erred in excluding certain aspects of the experts' proffered testimony, it properly excluded the central portions of their testimony, depriving Heller's claim of its needed evidentiary support.

* Honorable John T. Noonan, Jr., Senior Judge of the United States Court of Appeals for the Ninth Circuit, sitting by designation.

More specifically, the District Court was too restrictive in requiring Heller's medical expert to rely on published studies specifically linking Heller's illness with Shaw's product, and in requiring Heller's medical expert to **[**3]** rule out *all* alternative possible causes of her illness. However, it properly excluded this expert's causation testimony because his conclusion regarding the cause of Heller's illness was heavily based on a flawed temporal **[*150]** relationship between the installation of the Shaw carpet and the presence of Heller's illness. The District Court also properly excluded the testimony of Heller's environmental expert on the grounds that his environmental testing revealed levels of dangerous compounds in the air in Heller's home that were not significantly higher than background levels, and his methodology for extrapolating from these tests to estimate the (higher) levels of compounds at an earlier time was seriously flawed. Therefore, because the District Court did not abuse its discretion in excluding the key elements of Heller's experts' testimony necessary to prove causation, the grant of summary judgment will be affirmed.

I. Facts and Procedural History

On September 30, 1993, Heller, her husband Thomas, and their two children moved into a nine-year old house in West Chester, Pennsylvania. Shortly after the move, Thomas Heller experienced allergy symptoms. In November and December 1993, **[**4]** an allergist advised Mr. Heller to replace the carpeting in the home because cat hair from previous owners might have caused his allergic reactions. On December 13 and 14, 1993, the Hellers put new carpeting--manufactured by Shaw Industries--in certain rooms of their home, including the master bedroom on the first floor and a guest room on the second floor.

In late December 1993, Carol Heller began to experience respiratory problems, including asthma, breathing difficulty, wheezing, coughing, and dizziness. After seeking treatment from her father, a physician, Heller consulted Dr. Joseph Papano, an allergist and one of her two expert witnesses. ¹ **[**6]** Her first visit to Dr. Papano was on February 15, 1994. Dr. Papano took Heller's medical and family history, questioned her about her environment (whether there were cats or dogs in the home, etc.), and performed allergy tests, chest X-rays, and pulmonary function tests. Based on the history, tests, and a physical examination, Dr. Papano ruled out various possible causes of her respiratory problems. In February 1994, the doctor recommended that Heller contact Alan Todd of Todd Environmental Consultants (collectively "Todd") to test both **[**5]** the air quality in her home and the carpet. ² When Dr. Papano next saw Heller, on March 19, 1994, she was still experiencing problems, but informed him that her symptoms improved when she was out of her house. At this time, she brought the doctor a sample of the Shaw carpet, which he testified had a strong odor.

The Hellers contracted with Todd to perform the testing of the environment in the house and of the carpet. Todd initially tested for excessive levels of dust or other possible contaminants, finding nothing unusual. By April 7, 1994, the Heller family had moved out of their home in an attempt to eliminate Heller's respiratory problems. On April 14, 1994, Todd tested the air in the closet of one of the Hellers' bedrooms; the closet contained both some of the Shaw carpet and some carpet from an unknown manufacturer. Todd's initial test, conducted over approximately eight hours, found fourteen types of volatile organic compounds ("VOC"s) present in the air in **[**7]** the closet.

¹ Because, as discussed below, Dr. Papano relied heavily for his diagnosis on the temporal relationship between the installation of the Shaw carpet and the onset of Heller's illness, the date on which she began to experience her symptoms is a contested and important issue. Dr. Papano originally testified at his deposition that her symptoms began in "January 1994," and he so stated in his expert witness report. However, at the *Daubert* hearing, he testified that the symptoms began in "mid-January 1994." Heller testified at the *Daubert* hearing that her symptoms began in late December 1993 or early January 1994, while her father testified that they began either in mid-December or during the first two weeks of December. Given the conflicting testimony, we find no clear error in the District Court's reliance, in its findings following the *Daubert* hearing, on Heller's testimony that her symptoms began in late December 1993. See *Heller*, 1997 WL 535163, at *17 n.29.

² Dr. Papano's expert report represents that he referred Heller to Todd at her March 1994 visit, while Todd's expert report states that he was first contacted by Heller and did the initial testing in February. The District Court apparently credited Todd and we will not revisit this (supported) conclusion. Given that the initial home testing was performed by Todd in February 1994, Dr. Papano must have referred the Hellers to Todd in February.

[*151] Three weeks later, on May 5, 1994, the Shaw carpet was removed from the house. Less than a week later, on May 11, 1994, Todd again tested the air in the bedroom closet for eight hours. During the period between the two tests, no other changes were made in the house: no objects were added or removed, the windows remained closed, and no persons entered or left the by-now empty house. In the second test, Todd found only five types of VOCs present. Four of these were present in levels virtually indistinguishable from the initial readings. Therefore, nine compounds completely disappeared and one (benzene) remained present, but at lower levels. Todd's initial conclusion, in a May 23, 1994, letter to Heller, was that "none of the compounds identified would be expected to typically result in asthmatic or sensitization responses." (Later, however, in his first expert witness report, dated January 16, 1997, he opined that the compounds that disappeared or diminished were emitted from the Shaw carpet, and were "the likely source of [the Hellers'] irritation and related responses.")

The Hellers returned to the home briefly on May 11, 1994. Although the carpet had been removed **[**8]** six days earlier and the May 11 testing would reveal the presence of very few VOCs, Mrs. Heller again experienced "wheezing, shortness of breath and an irritated throat." The Hellers then left the house, never to return. In November 1994, they sold the home for less than they had paid for it a year earlier.

Dr. Papano's expert report stated that he performed a differential diagnosis, which involved ruling out possible causes of Heller's symptoms other than Shaw's carpet (including "an infectious cause"), and, based largely on the temporal relationship between her symptoms and the installation of the Shaw carpet, concluded that the Shaw carpet precipitated Heller's respiratory problems. As noted above, Alan Todd also offered his expert opinion (in his original expert report) that "to a reasonable degree of scientific certainty, . . . the illnesses suffered by the Heller family were caused by their prolonged exposure to the VOC's measured in their home and emitted by the carpeting manufactured by Shaw Industries."

In December 1995, the Hellers brought a diversity action against Shaw in the District Court for the Eastern District of Pennsylvania, under [28 U.S.C. § 1332](#), alleging **[**9]** breach of warranty, failure to warn, negligent and intentional misrepresentation, defective design, and violation of state consumer protection laws. The complaint sought compensatory and punitive damages for both personal injuries and property damage, as well as a medical monitoring award. To establish defective design and failure to warn, a plaintiff must prove that the defendant's product caused her injuries. Causation therefore was the primary focus of the District Court's inquiry and the primary disputed issue in this case.

Following extensive discovery, Shaw moved for summary judgment and, as an adjunct to that motion, moved *in limine* to exclude all of Heller's expert witness testimony. The District Court held a *Daubert* hearing over several days. It then filed an unpublished opinion and order, granting defendant's motions for exclusion of plaintiff's expert testimony and for summary judgment. See [Heller v. Shaw Indus., Inc., 1997 U.S. Dist. LEXIS 12399](#), No. Civ.A.95-7657, 1997 WL 535163 (E.D. Pa. Aug. 18, 1997).

On appeal, we review a District Court's decision to exclude expert testimony for abuse of discretion. See [Joiner, 118 S. Ct. at 517](#). The District Court's interpretation of the **[**10]** requirements of [Rule 702](#), however, is subject to plenary review. See [Paoli, 35 F.3d at 749](#). As to the District Court's entry of summary judgment for defendants, "we exercise plenary review, construing all evidence and resolving all doubts raised by affidavits, depositions, answers to interrogatories, and admissions on file in favor of the non-moving party." [Iberia Foods Corp. v. Romeo, 150 F.3d 298, 302 \(3d Cir. 1998\)](#).

Heller does not appear to dispute that, if we determine that the District Court properly excluded *all* of plaintiff's expert testimony, summary judgment for defendant was the proper course for the key claims of design defect and failure to warn. This is because, without either Dr. Papano's or Alan Todd's **[*152]** testimony, Heller would be left without any proof of causation, a necessary element for each of these claims. However, if we decide (as we do) that some of the testimony should have been admitted, we must determine whether that testimony is sufficient to create a material issue of fact on the causation issue. Most of our opinion will focus on the key underlying issue of the admissibility of Heller's expert witness testimony, on which the causation issue **[**11]** hinges. While there are other

issues in the case, including breach of warranty and misrepresentations, we will address these only briefly, for they are easily disposed of without extended discussion.

II. *Expert Witnesses: The Legal Background*

[Rule 702](#) provides: "If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert . . . may testify thereto in the form of an opinion or otherwise." Relying on the language of [Rule 702](#) and the liberal thrust of the Federal Rules of Evidence, the Supreme Court held in *Daubert* that expert testimony need be based only on a reliable and scientifically valid methodology that fits with the facts of a case. See [Daubert, 509 U.S. at 592-93](#).³ The Court listed four factors to guide a district court in its preliminary assessment of these requirements, but cautioned that these were guideposts and not required factors in each case. The factors are: (1) whether the methodology can and has been tested; (2) whether the technique has been subjected to peer review and publication; (3) the known or potential rate of error of the methodology; **[**12]** and (4) whether the technique has been generally accepted in the proper scientific community. See [id. at 593-94](#). The Court made clear that its listing of these factors should not obscure the fact that the district court's gatekeeper role is a flexible one, see [id. at 594](#) & n.12, and that the factors are simply useful signposts, not dispositive hurdles that a party must overcome in order to have expert testimony admitted. In this regard, a party seeking to exclude (or to admit) expert testimony must do more than enumerate the factors from *Daubert* (and the additional ones from *Paoli*, discussed below) and tally the number that are or are not met by a particular expert's testimony.

[13]** In *Daubert*, the Court noted that "vigorous cross-examination, presentation of contrary evidence, and careful instruction on the burden of proof are the traditional and appropriate means of attacking shaky but admissible evidence," and that, even if expert testimony is admitted, summary judgment might be warranted if a party has still failed to present sufficient evidence to get to the jury. [Id. at 596](#); see also [Paoli, 35 F.3d at 750 n.21](#). Clearly, the Court envisioned cases in which expert testimony meets the *Daubert* standard yet is "shaky," and cases in which admissible expert testimony provides only a "scintilla" of support for a claim or defense. Put differently, an expert opinion must be based on reliable methodology and must reliably flow from that methodology and the facts at issue—but it need not be so persuasive as to meet a party's burden of proof or even necessarily its burden of production.

In *Paoli*, filed barely a year after *Daubert*, we identified a number of factors that a district court might use in evaluating expert testimony in addition to the four factors listed in *Daubert*. The additional factors include: (1) "the existence and maintenance **[**14]** of standards controlling the technique's operation"; (2) "the relationship of the technique to methods which have been established to be reliable"; (3) the expert witness's qualifications; and (4) "the non-judicial uses to which the method has been put." [Paoli, 35 F.3d at 742 n.8](#). In *Paoli*, we explained that even if the judge believes "there are better grounds for some alternative conclusion," and that there are some flaws in the scientist's methods, if **[*153]** there are "good grounds" for the expert's conclusion, it should be admitted. [Id. at 744](#).⁴

We also emphasized in *Paoli* that the district court could not exclude the testimony simply because the conclusion **[**15]** was "novel" if the methodology and the application of the methodology were reliable. See [id. at 746 n.15](#). However, we rejected the plaintiffs' argument in *Paoli* (also urged strongly by the plaintiff here) that the district court had abused its discretion by examining the experts' conclusions. While "the focus, of course, must be solely on principles and methodology, not on the conclusions that they generate," [Daubert, 509 U.S. at 595](#), a

³ In *Daubert*, the Supreme Court interred the decades-old *Frye* doctrine, from [Frye v. United States, 54 App. D.C. 46, 293 F. 1013 \(D.C. Cir. 1923\)](#), which required that an expert's methodology be "generally accepted" within the scientific community before the expert's testimony could be admitted. See [Daubert, 509 U.S. at 588-89](#).

⁴ In addition to the "good grounds" requirement, in a diversity case such as this, state rules on the degree of certainty required of an expert's opinion apply. In Pennsylvania, a doctor can give an opinion on the cause of a plaintiff's illness if he or she can do so with a *reasonable degree* of medical certainty. See [Paoli, 35 F.3d at 750-52](#).

district court must examine the expert's conclusions in order to determine whether they could reliably follow from the facts known to the expert and the methodology used.⁵

[**16] III. Plaintiff's Expert Witnesses

In this case, Heller must demonstrate, as part of her *prima facie* case, that Shaw's carpet emitted VOCs into the air; that she inhaled these VOCs; that she has an injury; and that the VOCs were the cause of this injury. See [In re Paoli R.R. Yard PCB Litig., 916 F.2d 829, 860 \(3d Cir. 1990\)](#). The expert testimony of Alan Todd, who is a certified industrial hygienist, is integral to plaintiff proving the first of these elements, and would bolster a medical conclusion on causation by demonstrating that the level of VOCs present in the Heller home was significantly higher than the background levels typically present. Without his testimony, drawn from the tests he performed in the Heller household, Heller has adduced no evidence that the Shaw carpet installed in the Heller home emitted VOCs into the air (let alone emitted them at a level sufficient to cause her illness). Further, even if Todd's testimony is admitted and is sufficient to meet plaintiff's burden on this first element at the summary judgment stage, Dr. Papano's testimony is necessary to prove that Heller became sick. His testimony also is critical for proving that the Shaw carpet [**17] was the cause of Heller's illness. While Todd also offered his expert testimony regarding the fourth element, i.e., that the VOCs from the Shaw carpet caused Heller's illness, as we will discuss below, only Dr. Papano is qualified to testify as to this element.⁶

A. Dr. Papano

Shaw did not challenge Dr. Papano's qualifications, so we mention them only briefly here. Dr. Papano is board-certified in internal medicine and allergy-immunology. He has been a practicing physician for more than 35 years, and currently treats 60 to 80 patients per week. Dr. Papano has held a number of prominent positions at Bryn Mawr Hospital in suburban Philadelphia, [**18] and has taught fellows and residents in allergy and internal medicine.

Dr. Papano's written expert report, from January 1997, opines that he "can state with a reasonable degree of medical certainty, that both Mr. and Mrs. Heller's respiratory problems or difficulties [were] precipitated [by] the rugs installed in their home in December 1993." Dr. Papano also testified at the *Daubert* hearing that, following Mrs. Heller's visit in May 1994, "I concluded that the carpeting in her house was the major factor in her illness." The basis for Dr. Papano's conclusion was a differential diagnosis [**154] drawn from his examination of Heller, the results of a series of medical tests, review of Heller's personal and family medical history, and Heller's descriptions of her personal activities (smoking, etc.) and environmental conditions ("cats, dogs, the type of heating system, rugs, pillows, things of that sort").

Dr. Papano testified that he also relied on the temporal relationship between Heller's exposure to the Shaw carpet and the onset of her symptoms, as well as information from Todd Environmental Consultants after its testing of the Heller home in April and May 1994. Finally, Dr. Papano [**19] relied on his more than thirty years of experience treating patients with allergy-related medical problems and his knowledge of environmental causes of respiratory problems gained at professional seminars he attended.

The District Court excluded *all* of Dr. Papano's testimony, largely because he could point to no studies indicating at what level the VOCs detected in the Heller home could cause symptoms such as those experienced by Mrs. Heller, see *Heller*, 1997 WL 535163, at *15; his differential diagnosis "failed to rule out all alternative possible causes of

⁵ The Advisory Committee on the Federal Rules of Evidence has proposed changes to [Rule 702](#) that would reflect the standards from *Daubert* (and *Paoli*), requiring that an expert's testimony be based on reliable facts, be the product of reliable principles and methodology, and be based on a reliable application of these principles and methods to the facts of the case. See [Fed. R. Evid. 702](#) (Preliminary Draft 1998).

⁶ We do not focus on the second element, that Heller inhaled the VOCs. If she is able to prove, through her expert witnesses' testimony, that the Shaw carpet installed in the home emitted VOCs, that she became ill, and that the VOCs caused her illness, it certainly would be within a jury's purview to find that Heller had inhaled the VOCs, without further direct proof.

Carol Heller's illness," *id.* at *16; and the court found that the temporal relationship on which Dr. Papano relied was weak, *see id.* at *17. We address each of these in turn.

1. Lack of Studies

The District Court faulted Dr. Papano for citing "no research to support his contention that the levels of VOCs detected by Todd Environmental can and did cause the type of illness allegedly experienced by [Mrs. Heller]." *Id.* at *15. The court found that the lack of studies supporting Dr. Papano's conclusion was a "defect" in his testimony. *Id.* We do not believe that the court's reading of [Rule 702](#)--as **[**20]** requiring research studies supporting a finding of general causation--is correct. Assuming that Dr. Papano conducted a thorough differential diagnosis (*see infra* Part III.A.2) and had thereby ruled out other possible causes of Heller's illness, and assuming that he had relied on a valid and strong temporal relationship between the installation of the carpet and Heller's problems (*see infra* Part III.A.3), we do not believe that this would be an insufficiently valid methodology for his reliably concluding that the carpet caused Heller's problems.

A number of courts, including our own, have looked favorably on medical testimony that relies heavily on a temporal relationship between an illness and a causal event. *See, e.g., Zuchowicz v. United States, 140 F.3d 381, 385 (2d Cir. 1998); Kannankeril v. Terminix Int'l, Inc., 128 F.3d 802, 809 (3d Cir. 1997).* The temporal relationship will often be (only) one factor, and how much weight it provides for the overall determination of whether an expert has "good grounds" for his or her conclusion will differ depending on the strength of that relationship. For example, if there was a minor oil spill on the Hudson River on the same **[**21]** day that Heller began experiencing her symptoms in West Chester, Pennsylvania, and she recovered around the time the oil was cleaned up, a proper differential diagnosis and temporal analysis by a well-qualified physician such as Dr. Papano could not possibly lead to the conclusion that the oil spill caused Heller's illness. *See, e.g., Paoli, 35 F.3d at 745* (both the methodology and the application of that methodology must be reliable). Conversely, "if a person were doused with chemical X and immediately thereafter developed symptom Y, the need for published literature showing a correlation between the two may be lessened." *Cavallo v. Star Enter., 892 F. Supp. 756, 774 (E.D. Va. 1995), aff'd in relevant part, 100 F.3d 1150, 1159 (4th Cir. 1996), cert. denied, 118 S. Ct. 684 (1998).*

The present case falls between these two hypotheticals. In this middle area, we do not believe that *Daubert* and *Paoli* require a physician to rely on definitive published studies before concluding that exposure to a particular object or chemical was the most likely cause of a plaintiff's illness. Both a differential diagnosis and a temporal analysis, properly performed, would generally **[**22]** meet the requirements of *Daubert* and *Paoli*. While again emphasizing that the *Daubert/Paoli* factors are simply guideposts, we note that differential diagnosis "consists of a testable hypothesis," has been peer reviewed, contains standards for controlling its operation, **[*155]** is generally accepted, and is used outside of the judicial context. *Paoli, 35 F.3d at 742 n.8.*

The question we have thus posed is whether the expert's conclusion can be considered reliable if it is based on these scientifically valid methods, but is not based on published studies. We acknowledge that a number of courts have answered this question in the negative. *See, e.g., Moore v. Ashland Chem. Inc., 151 F.3d 269, 278 (5th Cir. 1998)* (en banc) (holding that, absent a "compelling" situation such as the *Cavallo* example above, a temporal relationship is to be given little weight when there are few scientific studies supporting a medical expert's specific causation diagnosis), *cert. denied, 143 L. Ed. 2d 541, 119 S. Ct. 1454 (U.S. 1999); Cavallo, 892 F. Supp. at 766-69* (excluding expert testimony on causation primarily because "there is no support for this causation theory **[**23]** in the scientific literature"). *But see Kennedy v. Collagen Corp., 161 F.3d 1226, 1229 (9th Cir. 1998)* (finding district court abused its discretion by excluding expert testimony that was based on reliable methodology simply because "no epidemiological or animal studies" linked defendant's product to plaintiff's disease).

The Supreme Court has held that it was not an abuse of a district court's discretion to exclude expert testimony when there was "too great an analytical gap between the data [of scientific studies] and the opinion proffered," *Joiner, 118 S. Ct. at 519*, but we do not read the Supreme Court as requiring a medical expert to always rely on published studies indicating the exposure necessary to cause a particular illness. Rather, given the tenuous link in *Joiner* between plaintiff's exposure to PCBs and the onset of his cancer a number of years later, the lack of studies

linking PCBs to cancer in humans left only "the *ipse dixit* of the expert" to support his conclusion. *Id.* Therefore, the Court held that it was not an abuse of discretion for the district court to exclude the expert's testimony. *See id.*

Given the liberal thrust of the Federal **[**24]** Rules of Evidence, the flexible nature of the Daubert inquiry, and the proper roles of the judge and the jury in evaluating the ultimate credibility of an expert's opinion, we do not believe that a medical expert must always cite published studies on general causation in order to reliably conclude that a particular object caused a particular illness. *Cf. McCulloch v. H.B. Fuller Co.*, [61 F.3d 1038, 1043 \(2d Cir. 1995\)](#) (affirming admission of treating doctor's testimony despite the fact that he "could not point to a single piece of medical literature that says glue fumes cause throat polyps"). To so hold would doom from the outset all cases in which the state of research on the specific ailment or on the alleged causal agent was in its early stages, and would effectively resurrect a *Frye*-like bright-line standard, not by requiring that a methodology be "generally accepted," but by excluding expert testimony not backed by published (and presumably peer-reviewed) studies. We have held that the reliability analysis applies to all aspects of an expert's testimony: the methodology, the facts underlying the expert's opinion, the link between the facts and the conclusion, *et alia*. **[**25]** *See Paoli*, [35 F.3d at 743-45](#). However, not only must each stage of the expert's testimony be reliable, but each stage must be evaluated practically and flexibly without bright-line exclusionary (or inclusionary) rules.

In the actual practice of medicine, physicians do not wait for conclusive, or even published and peer-reviewed, studies to make diagnoses to a reasonable degree of medical certainty. Such studies of course help them to make various diagnoses or to rule out prior diagnoses that the studies call into question. However, experience with hundreds of patients, discussions with peers, attendance at conferences and seminars, detailed review of a patient's family, personal, and medical histories, and thorough physical examinations are the tools of the trade, and should suffice for the making of a differential diagnosis even in those cases in which peer-reviewed studies do not exist to confirm the diagnosis of the physician. The Federal Rules of Evidence recognize as much. *See, e.g., Fed. R. Evid. 703* advisory committee's note ("[A] physician in his own practice bases his diagnosis on information from numerous sources and of considerable variety The physician **[**26]** makes life-and-death decisions in **[*156]** reliance upon them. His validation, expertly performed and subject to cross-examination, ought to suffice for judicial purposes.").

We repeat that all of these reliable methods for making a diagnosis cannot sanitize an otherwise untrustworthy conclusion. *See Paoli*, [35 F.3d at 745-46](#); *see also Joiner*, [118 S. Ct. at 519](#) ("A court may conclude that there is simply too great an analytical gap between the data and the opinion proffered."). In this case, however, there is certainly evidence in the record--from Shaw's own records and from reliable studies--that carpets emit VOCs and that VOCs can cause certain health problems. This might be sufficient to give Dr. Papano "good grounds" for making his conclusion, even though the District Court (or a jury) may not agree with that conclusion. Therefore, to the extent that the District Court excluded Dr. Papano's testimony on the basis that it was not grounded in scientific studies, it erred. However, it was not necessarily error to exclude Dr. Papano's causation conclusion as unreliable if he relied on no scientific studies and the remaining foundation for his conclusion was shaky.

2. Dr. Papano's Differential **[**27]** Diagnosis

The District Court also found it important that Dr. Papano "failed to rule out *all* alternative possible causes of Carol Heller's illness." *Heller*, 1997 WL 535163, at *16 (emphasis added). Applying plenary review, we hold that this is a more stringent standard for a medical expert's differential diagnosis than is required under [Rule 702](#). A medical expert's causation conclusion should not be excluded because he or she has failed to rule out every possible alternative cause of a plaintiff's illness. As Professor Capra, Reporter to the Advisory Committee on the Federal Rules of Evidence, has put it:

To require the experts to rule out categorically all other possible causes for an injury would mean that few experts would ever be able to testify

. . . Obvious alternative causes need to be ruled out. All possible causes, however, cannot be and need not be eliminated before an expert's testimony will be admitted.

Daniel J. Capra, *The Daubert Puzzle*, [32 Ga. L. Rev. 699, 728 \(1998\)](#).

Differential diagnosis, as we noted in *Paoli*, is "the basic method of internal medicine." [Paoli, 35 F.3d at 755](#). Dr. Papano engaged in this basic **[**28]** method in a reliable manner, ordering standard laboratory tests, physically examining the plaintiff, taking medical histories, and considering alternative causes of the plaintiff's illness. See [id. at 755, 758](#). That he used this technique to "testify to a novel conclusion" is not sufficient grounds for excluding his testimony. [Id. at 759 n.27](#). Dr. Papano was not required to rule out *all* alternative possible causes of Heller's illness. Rather, only "where a defendant points to a plausible alternative cause and the doctor offers *no* explanation for why he or she has concluded that was not the sole cause, that doctor's methodology is unreliable." *Id.*

When cross-examining Dr. Papano at the Daubert hearing, Shaw offered a number of plausible alternative causes, including dust from other carpets, benzene and 2-butoxyethanol from other sources, and paint and new hardwood floors in the house. Dr. Papano did not offer detailed explanations for why he concluded that these were not the causes of plaintiff's illness, but his responses, grounded in the alleged temporal relationship, the results of Todd's testing showing a reduction in VOCs when the carpet was removed, and Heller's **[**29]** medical history and physical examination, certainly are more than "*no* explanation." See, e.g., App. at A602 (Dr. Papano's discussion of his consideration of other possible causes). Had the District Court applied the proper standard for evaluating a differential diagnosis, we might conclude that it had not abused its discretion in finding that Dr. Papano's responses were inadequate, but it did err in requiring him to "rule out all alternative possible causes."

As we concluded in *Paoli*, a physician need not conduct every possible test to rule out all possible causes of a patient's illness, "so long as he or she employed sufficient diagnostic techniques to have good grounds for his or her conclusion." [Paoli, 35 F.3d at 761](#). More recently, we held that a **[*157]** district court erred in excluding expert medical testimony because a defendant's suggested alternative causes (once adequately addressed by plaintiff's expert) affect the weight that the jury should give the expert's testimony and not the admissibility of that testimony. See [Kannankeril, 128 F.3d at 808](#). In *Kannankeril*, we held that even absent hard evidence of the level of exposure to the chemical in question, **[**30]** a medical expert could offer an opinion that the chemical caused plaintiff's illness. See [id. at 809](#). The medical expert there relied primarily on the temporal relationship and the nature of the plaintiff's complaints, as in the present case. While the potential harm of the chemical in that case was clearer than in this case, there was also some information indicating that there may not have been a harmful level of the chemical in Kannankeril's home. Nonetheless, we emphasized that the district court should take care not to "mistake credibility questions for admissibility questions." *Id.* If the medical expert's "opinion on causation has a factual basis and supporting scientific theory" that is reliable, it should be admitted. *Id.*

3. Temporal Relationship

Neither Heller nor Dr. Papano disputes the absence of definitive studies establishing the level at which the VOCs detected in the Heller home could cause respiratory illnesses such as those Heller experienced. Nor do they dispute that studies linking Shaw carpeting to such illnesses do not exist. Rather, they rely heavily on the temporal relationship between the installation of the carpeting and the onset of Heller's **[**31]** illness, as well as the fact that she appeared to improve in health when she was away from her home. As we noted in Part III.A.1 *supra*, we do not believe that the lack of studies linking an alleged defective product to a plaintiff's illness is fatal to a plaintiff's case on causation. However, as noted, some reliable basis for a causation conclusion must exist--and here, that basis was largely the alleged temporal relationship between the installation (and removal) of the Shaw carpet and the presence of Heller's illness.

The District Court relied on three major weaknesses in the temporal relationship to find Heller's burden to prove causation unmet. We review the factual findings of the District Court for clear error and can find none, as the background facts to its critique of Dr. Papano's temporal conclusion are undisputed: (1) the Shaw carpeting was installed in the Heller home in mid-December 1993; (2) Carol Heller first experienced respiratory problems no earlier than late December 1993; (3) Mr. and Mrs. Heller experienced renewed symptoms upon returning to the home in May 1994, almost a week after the carpet had been removed; and (4) although Dr. Papano originally relied on **[**32]** the same temporal relationship to conclude that the carpeting was the cause of Thomas Heller's illness, Mr. Heller actually experienced his symptoms prior to the installation of the Shaw carpet.

In reaching its legal conclusion regarding the temporal relationship, the court first noted that Heller did not experience symptoms until at least two weeks after the Shaw carpeting was installed.⁷ Dr. Papano himself testified that a reaction to VOCs in the home would typically occur within 24 hours of exposure to the VOCs. See App. at A638. While Heller contends that this can be explained by her use of an upstairs bedroom (rather than the downstairs master bedroom) after the Shaw carpet was first installed, she admitted that *both* of these rooms contained the Shaw carpet.

[33]** Not only did Heller's symptoms not appear until at least one or two weeks after the Shaw carpeting was installed, but they remained after the carpet was removed in May 1994. The District Court properly faulted Dr. Papano's testimony for not accounting for this fact as well. Plaintiff attempts to **[*158]** explain this weakness in the temporal relationship by reference to the "sink" effect, by which VOCs sink into objects other than the ones from which they are emitted and then are re-emitted at later times. See Appellants' Br. at 21 n.6. This explanation is dubious, however, as the air was actually measured on the day Heller returned to the home and experienced renewed symptoms--and there were virtually no VOCs present at that time. Further, this "sink" effect theory was disavowed by Heller's own environmental expert. See App. at A882-883. Most importantly, it is not evident that Dr. Papano relied on any "sink" effect or any other explanation for why Heller continued to suffer ill effects from the Shaw carpeting after it had been removed from the house. Finally, the District Court noted that Dr. Papano's temporal analysis failed to explain why Thomas Heller (who Dr. Papano also concluded **[**34]** suffered ill effects from the Shaw carpet) exhibited allergy symptoms *prior* to the installation of the Shaw carpet.

These weaknesses, according to the District Court, "disprove the existence of a temporal relationship." *Heller*, 1997 WL 535163, at *17. While we review such a conclusion for abuse of discretion, as noted above, our review of the court's legal analysis--i.e., whether it properly followed [Rule 702](#) as prescribed in *Daubert* and *Paoli*--is plenary. The court's analysis of the temporal relationship included the criticism that "plaintiffs proffer no statistical evidence to show the existence of a statistically significant correlation" between the Hellers' symptoms and their exposure to the Shaw carpet. *Id.* However, a physician's diagnosis, based in part on a strong temporal relationship between symptoms and exposure, need not necessarily be supported by "a statistically significant correlation." What is required is that the physician have "good grounds" for his or her diagnosis. See [Paoli, 35 F.3d at 744](#) (noting that, even if the judge believes "there are better grounds for some alternative conclusion" and that there are some flaws in the expert's methods, **[**35]** if there are "good grounds" for the expert's conclusion, it should be admitted). Further, when the temporal relationship is strong and is part of a standard differential diagnosis, it would fulfill many of the *Daubert/Paoli* factors. See [id. at 742 n.8](#).

Here, however, we have no problem concluding that the temporal relationship between the exposure to the Shaw carpeting and the onset of Heller's illness was questionable at best and exculpatory at worst. While the district court may not reject an expert's conclusion simply because the court finds it wanting, it is surely within the court's province to ensure that the conclusion, particularly a medical expert's ultimate conclusion on causation, "fits" with the data alleged to support it. See [id. at 746](#) ("The expert's view that a particular conclusion 'fits' a particular case must itself constitute scientific knowledge . . ."). Had the Hellers experienced a prompt reaction at the time the Shaw carpeting was installed in mid-December 1993, and had they suffered no reaction upon return to their home after the Shaw carpet was removed in May 1994, this would be the type of temporal relationship that might reliably support a **[**36]** conclusion that the carpet was the cause of plaintiff's illness. However, that is not the case here.

4. Dr. Papano's Testimony: Summary and Conclusion

We have explained that the District Court erred to the extent that it required Dr. Papano's testimony to be backed by scientific studies linking the type and level of VOCs detected in the Heller home to Heller's illness, and to the extent that it required Dr. Papano to rule out *all* other possible causes of Heller's illness before concluding that the Shaw

⁷ Plaintiff relies on the testimony of her other expert, Alan Todd, to establish the level of VOCs at the time the carpet was installed in mid-December. While we find serious problems with his calculations, see *infra* Part III.B.2, we note that the level of VOCs in mid-December would appear immaterial, as Heller did not experience any adverse reactions until at least one or two weeks later, when, according to plaintiff's own experts, the level of VOCs would be substantially lower.

carpet was the cause. The District Court could, however, properly consider the fact (rather than requiring it as a prerequisite to admissibility) that Dr. Papano relied on few, if any, studies linking exposure to the VOCs allegedly emitted by the Shaw carpet to the illnesses suffered by Heller. It could also properly consider Dr. Papano's (weak) responses to Shaw's proffered alternative theories on the cause of Heller's illness in evaluating whether he truly had "good grounds" to arrive at the causation conclusion he reached.

[*159] Dr. Papano relied extremely heavily on the temporal relationship between the installation of the carpet and Heller's illness, and the District Court did **[**37]** not err in concluding that this relationship was unreliable. Without either scientific studies pointing to VOCs of the type and amount detected as the culprit *or* a reliable temporal relationship, Dr. Papano was left with no valid means for concluding that the Shaw carpet was the cause of Heller's illness. Dr. Papano's conclusion had to "fit" with the data and the methodology that precedes it. See [Paoli, 35 F.3d at 746](#). Even if the data (e.g., the medical history, the laboratory studies, evidence of VOCs in the Heller home) and the methodology (i.e., the differential diagnosis) were reliable, the District Court did not err in finding that the conclusion Dr. Papano reached did not reliably flow from this data and methodology. Under these circumstances, the District Court did not abuse its discretion in ultimately deciding to exclude Dr. Papano's testimony regarding the cause of Heller's illness.⁸

[38]** B. Alan Todd

Plaintiff's second expert witness, Alan Todd, of Todd Environmental Consultants, opined in his initial expert report that "the illnesses suffered by the Heller family were caused by their prolonged exposure to the VOC's measured in their home and emitted by the carpeting manufactured by Shaw Industries." Todd based his conclusion on his testing of the air in a closet of the Heller home in which the Shaw carpet had been installed, and on his extrapolation from the results of these closet tests. He thereby estimated the level of VOCs emitted by the Shaw carpet at the time it was installed, approximately four months prior to his testing. We note preliminarily that we are doubtful that a non-medical expert such as Todd is qualified to testify as to the cause of someone's illness.⁹ We need not address that issue here, however, because we conclude that the District Court did not abuse its discretion in excluding Todd's extrapolations as being unreliable so that any arguable basis for Todd's causation conclusion was missing, making it appropriate for the District Court to exclude Todd's causation testimony.

[39]** Todd is a certified industrial hygienist, who consults on environmental problems in occupational and residential settings. His qualifications were not challenged by defendant, though as we discuss below, his methodologies were thoroughly attacked. Because Heller must show that her exposure to VOCs was at a greater level than "the normal 'background' level," [Paoli, 916 F.2d at 860-61](#), and that this exposure came from defendant's carpet, see [id. at 860](#), Todd's testimony was necessary for her to survive summary judgment. Todd testified that, at

⁸We add that the District Court should not necessarily have excluded *all* of Dr. Papano's testimony. In many cases, a treating physician whose methods and data are reliable, but whose causation conclusion is excluded as unreliable, may still have other reliable testimony to offer. In such a case, the medical expert should be permitted to "testify about his examination of [the plaintiff], the tests he conducted, and the diagnosis he reached," [Moore, 151 F.3d at 273](#), as these are all based on reliable methods. See also [Cavallo, 892 F. Supp. at 770](#) ("There is no question that Dr. Bellanti is qualified to testify regarding the *nature* of Ms. Cavallo's illnesses Rather, the focus of the dispute is whether his opinion regarding the *cause* of these illnesses is scientifically valid and therefore admissible under *Daubert*." (first emphasis added)). Thus, even if it was proper to exclude Dr. Papano's expert testimony regarding the cause of Heller's illness, as we conclude it was, testimony as to his examination and treatment of her illness was almost certainly relevant and reliable. It would be relevant to at least one of the elements in most of Heller's claims, i.e., whether or not she suffered an injury (as well as the extent of her injuries, a relevant factor in any damages analysis). Of course, without Dr. Papano's causation testimony, summary judgment may still have been warranted--and we conclude that it was--because without it there was insufficient evidence of causation to get to the jury.

⁹While Todd was knowledgeable about studies on VOCs and illness, and on recommended maximum occupational VOC levels, he is not a physician and did not examine the Hellers nor discuss with them their symptoms or their medical histories. Thus, whatever his qualifications for testifying about the source and level of VOCs in the Hellers' house or his expertise regarding dangerous levels of VOCs, his qualification to offer an opinion on the ultimate cause of the Hellers' illnesses is another matter.

the time the Shaw carpet was installed (December [*160] 13-14, 1993), the level of benzene in the air in the Heller home was approximately 1712 parts per billion ("ppb"), and that this benzene came from the Shaw carpet. He also estimated that, at that time, the level of other VOCs was approximately 11,469 ppb, and that these VOCs came from the Shaw carpet. If his methodologies were reliable, and his application of these methodologies to the facts of the case was reliable, his conclusion that there were VOCs, emitted from Shaw's carpet, at levels higher than background levels could support a proper medical diagnosis that the Shaw carpet caused [**40] the plaintiff's illness.

1. Subtraction Methodology ¹⁰

Todd's method for determining the source and level of VOCs in the Heller house was to take air samples in a bedroom closet before and after the Shaw carpet had been removed from the house (and the closet). Comparing the two measurements, he determined the amount of VOCs emitted by the Shaw carpet, the only item present for the first test and absent for the second one. If the methodology for collecting air samples and for measuring the VOCs present in the air was valid and reliable, and the difference in the level of VOCs was significant, this part of Todd's testimony would be probative of whether or not the Shaw carpeting emitted VOCs, and should have been admitted.

While the District Court faulted Todd's subtraction [**41] methodology on a number of counts, we uphold its decision to exclude this testimony largely because the conclusions Todd reached could not reliably flow from the data and methodology he used. We first consider the District Court's criticisms of Todd's subtraction methodology (not all of which we find warranted) before turning to our own critique of his testimony.

The District Court found that the studies cited by Todd for the proposition that carpet such as Shaw's could cause Heller's illness did not support this conclusion. *See Heller*, 1997 WL 535163, at *9. We address this aspect of the matter in the margin, for, given our ultimate conclusion, we need not decide whether the District Court's analysis of the studies was an appropriate factor in determining whether Todd's subtraction methodology itself was valid and reliable. ¹¹

[**42] In addition, although Todd testified that he used an accepted methodology for collecting the air samples and described this method in detail, Shaw and the District Court criticized him for not using some other test, specifically a closed chamber laboratory test. While the latter is an accepted test for measuring compounds in new carpet, it is neither the only nor necessarily the best test for measuring VOCs from carpet already installed in a home. Further, the record provides ample evidence that laboratory tests and on-site tests produce similar results, *see, e.g.*, App. at A88, and defendant's own expert conducted on-site tests in a number of carpet-emission studies, *see id.* at SA0892, SA1013, SA1030. [*161] That expert also admitted using in a prior study essentially the same

¹⁰ Although not so labeled by Todd, the parties and the District Court utilized the terms "subtraction methodology" and "back-extrapolation methodology" to describe Todd's two major methodologies. For the sake of consistency, we will do likewise.

¹¹ In our view, the record *can* be read to support Todd's claim that carpeting such as Shaw's can emit some of the VOCs detected in the Heller home and may cause illnesses similar to those suffered by Heller after prolonged exposure. In any event, we do not believe that unequivocal studies are required before a qualified expert may opine that a product emits a certain compound or causes a certain irritation, if the basis for the opinion is otherwise reliable and scientifically valid.

Further, this aspect of Todd's testimony was based on first-hand, field testing of the object in question--the Shaw carpet. If Todd was qualified to conduct such tests, and if his means of collecting air samples was scientifically valid and the initial conclusion he drew--that the Shaw carpet was the source of a certain level of VOCs--was reliably drawn from the field testing, this testimony would be both reliable and relevant. We note that this is not a case in which a party sought to avoid the application of *Daubert* by labeling such testing "non-scientific." *See, e.g., Carmichael v. Samyang Tire, Inc.*, 131 F.3d 1433, 1435-36 (11th Cir. 1997) (finding that testimony based on "skill- or experience-based observation," rather than on "application of scientific principles or theories," was not subject to *Daubert*), *cert. granted sub nom. Kumho Tire Co. v. Carmichael*, 141 L. Ed. 2d 711, 118 S. Ct. 2339 (1998). Here, plaintiff argued that Todd's testimony met the requirements of *Daubert* in that it was reliable and valid.

"subtraction method" used by Todd. See *id.* at A1152-1157. ¹² Properly performed, such on-site tests would appear to meet most of the factors suggested in *Daubert* and *Paoli*.

[43]** Finally, the District Court placed great weight on Todd's alleged failure to "insure that other variables did not [affect] the air sampling tests." *Heller*, 1997 WL 535163, at *12. However, Todd testified that the contents of the closet (and the house) remained constant and that the environmental conditions in the house were essentially static (i.e., no persons came or went, the windows were not opened, the rate of air flow was not changed, etc.). While it is true that the concentration of VOCs is affected by more than the emission from a source such as carpeting, a substantial decline in the amount of VOCs would constitute strong (and reliable) evidence that at least some of these VOCs were coming from the Shaw carpet--the only item that was removed before the lower readings were taken.

Our decision does not turn, however, on the validity of Todd's air sampling methodology, i.e., on whether the testing was unreliable because he did not conduct different tests or did not control for other possible sources of VOCs. This is because the District Court was correct to question the reliability of Todd's conclusions. The level of VOCs detected by Todd's closet tests, even if they **[**44]** could all be attributed to the Shaw carpet, were substantially lower than any amounts ever known or believed to cause illnesses in humans; in fact, they appear to be extremely close to the background amounts (i.e., the levels naturally occurring in the air) for each of the VOCs. ¹³ **[**45]** A number of studies cited by the parties and contained in the record have concluded that any ill effects from these particular VOCs (and related ones) only occur at much higher levels than those found in the Heller home. See, e.g., App. at SA0835-0840 (finding basic irritation at 50-750 ppb of VOCs; headaches at 750-6250 ppb; and additional neurotoxic effects at levels above 6250 ppb); *id.* at A126 (reporting pulmonary irritation at 275 ppb; slight sensory irritation at 600 ppb); *id.* at SA0210 (finding that persons exposed to 25,000 ppb of benzene for eight hours demonstrated no acute effect). Another major study found that the background levels of benzene averaged 5 ppb overall and about 3 ppb indoors, see *id.* at SA0200, actually above the levels (2.2 ppb) detected in the Heller home in April, when the Shaw carpet was still in the house. ¹⁴

¹² The court also faulted Todd's testimony because he "did not conduct further tests to ascertain whether changes in the levels of VOCs were attributable to the removal of the carpet or whether the changes were attributable to the natural fluctuation in VOC levels within the home." *Heller*, 1997 WL 535163, at *12. It is not clear what "further tests" the District Court would have required. Todd did not take snapshot tests at single moments, which would have been subject to natural fluctuations and random error; such tests likely would not be reliable enough to meet the *Daubert* standard. Rather, Todd took air sample readings over eight hours on one day, with the carpet present, and then took readings for eight hours on a second day, without the carpet present. Such prolonged readings may be sufficient to account for "natural fluctuations in VOC levels."

¹³ We note that a number of the VOCs allegedly attributable to the Shaw carpet were detected at levels well below the maximum amounts recommended by various federal agencies and professional groups. For example, only 2.22 ppb of benzene was detected in April 1994; the lowest suggested limit for exposure to benzene is 500 ppb. Other VOCs detected in the closet, with the maximum amount attributable to the Shaw carpet and the lowest recommended limit, include:

VOC	Amount Found (in ppb)	Recommended Limit (in ppb)
2-Butoxyethanol	5.60	20,000
Carbon Tetrachloride	0.13	2,000
Cumene	0.11	50,000
Methyl Chloroform	0.09	200,000

See Richard J. Lewis, Sr., *Hazardous Chemicals Desk Reference* 113, 180, 235, 318, 745 (4th ed. 1997). We note that these limits are for *long-term* occupational exposure and assume exposure *at these levels* for 40 hours per week, indefinitely.

¹⁴ Unfortunately, comparing these studies and industry documents to Todd's findings can be difficult, as the latter are reported in terms of ppb (parts per billion), while many of the studies and industry documents measure air concentration in mg/m³

[*162] Todd attempted to address this shortcoming in his testimony by dividing the suggested occupational limits by 420, based on two assumptions whose validity is problematic. First, because the limits are based on a 40-hour work week and there are potentially 168 hours per week in which a person could occupy her home (if she never left), Todd reduced the limits by 4.2. Then, because **[**46]** the occupational limits are based on an average healthy adult, Todd testified that it is standard practice to reduce these limits further by a factor of 100, to account for the fact that homes include children, older adults, unhealthy persons, etc. As a result, he opined that the limit for exposure to benzene in the home is actually approximately 1.2 ppb (i.e., 500 ppb / 420), slightly lower than the amount attributable to the Shaw carpet.

This methodology is suspect. In one study in the record, the American Society of Heating, Refrigeration, and Air Conditioning Engineers ("ASHRAE") is cited as recommending a maximum level of contaminants arrived at by dividing the OSHA limit by 10, see App. at SA0860-0861, for essentially the same reason that Todd gave for dividing the permissible limits by 420. The OSHA limit for benzene is 1000 ppb; the ASHRAE limit, then, would be 100 ppb, still well above the amount detected in the Heller home in April (2.22 ppb). The OSHA limit for 2-butoxyethanol is 25,000 ppb, making the ASHRAE limit 2500 ppb, significantly higher than the amount detected in the Hellers' house (5.60 ppb). At all events, even if the methodology is valid, the levels **[**47]** measured in April (the earliest period at which Todd actually took air concentration measurements) do not even approach the (modified) recommended maximums for any of the other VOCs.

Thus, while the closet tests conducted by Todd were not necessarily unreliable, because the level of VOCs detected and (arguably) attributable to the Shaw carpet were so low and so close to background levels, the District Court did not abuse its discretion in excluding Todd's testimony that the Shaw carpet was emitting VOCs sufficient to cause Heller's illness--a conclusion that was unreliable if based on the closet tests alone. Todd, however, attempted to reinforce his closet tests--and to provide a stronger foundation for his opinion about the dangerous level of VOCs in the house--by introducing his back-extrapolation methodology in a supplemental expert witness report (issued in March 1997, following his original January 1997 report). We turn to this aspect of his testimony.

2. Back-Extrapolation Methodology

If Todd's sampling of the air in the closet: (1) was reliable and adequately controlled for factors other than the Shaw carpet, and (2) demonstrated that the Shaw carpet was emitting VOCs at **[**48]** potentially harmful levels, his testimony would be sufficiently reliable to meet the *Daubert* standard and hence would be admissible. While we believe that the first proposition may be true, as noted above, the closet tests themselves fail to demonstrate the second. If it was possible to use the results of the closet tests to estimate, in a scientifically valid way, the level of VOCs emitted by the carpet at some earlier time, and if these estimated levels were potentially harmful, again, Todd's testimony would be reliable and relevant. We express no opinion as to whether extrapolation back in time, using known levels of compounds and a scientifically valid mathematical formula for the extrapolation, would meet the standards of [Rule 702](#) and *Daubert*. Cf. [Ruiz-Troche v. Pepsi Cola of P.R. Bottling Co.](#), 161 F.3d 77, 85 (1st Cir. 1998) (approving of a back-extrapolation and half-life methodology that "has been subjected to, and survived, the rigors of testing, publication, and peer review, and . . . appears to have won significant (if not universal) acceptance within the scientific community"). Here, however, it is clear that Todd's formula for his extrapolation was based on speculation **[**49]** and estimation that was subject to gross error, and that the District Court did not abuse its discretion in excluding Todd's testimony **[*163]** based on the back-extrapolation.¹⁵ Indeed, we doubt that

(milligrams per cubic meter) or $\mu\text{g}/\text{m}^3$ (micrograms per cubic meter). The conversion from one to the other is different for every compound. For benzene, it is about 3 $\mu\text{g}/\text{m}^3$ for every 1 ppb; for other compounds, it ranges from about 3 $\mu\text{g}/\text{m}^3$ for every 1 ppb to 7 $\mu\text{g}/\text{m}^3$ for every 1 ppb. For the sake of analyzing Todd's testimony, we have made rough conversions, using 4 $\mu\text{g}/\text{m}^3$ for every 1 ppb. No difference in outcome would result from using another conversion equation.

¹⁵ Plaintiff relies heavily on a Louisiana state case to support Todd's back-extrapolation theory. See Appellants' Br. at 38-40. The judgment in that case, however, has been reversed and a new trial ordered, specifically because the trial court failed to hold a *Daubert* hearing and to find whether the *Daubert* criteria were met, as required by Louisiana law. See *Caubarreaux v. E. I. duPont de Nemours*, 714 So. 2d 67, 71-72 (La. Ct. App. 1998).

Todd's back-extrapolation methodology would meet even one of the eight suggested factors from *Daubert* and *Paoli*.

Heller argues that the back-extrapolation method is "a standard reversibility of chemical processes equation," Appellants' Br. at 27, but provides no support for the reliability of Todd's equation or for the suggested relationship between chemical **[**50]** half-lives and the level of VOCs in the air. Todd's back-extrapolation method relies on at least three questionable assumptions: (1) the concentration of VOCs in the air declines exponentially by half-lives (i.e., the level of VOCs are cut in half every X days or weeks or years); (2) the half-life of VOCs in the air can be estimated based on information on the decay curve of VOC emissions from carpets; and (3) the concentration of VOCs in the air is not affected by anything other than its natural half-life decline.

None of these assumptions, however, appears supported by reliable scientific methods or the reliable application of any valid theory. In fact, Todd admitted as much in his own testimony and expert report. See, e.g., App. at A350-351, A761-762; *id.* at SA0247 (Todd's Expert Report: "The precise magnitude of difference quantitatively in off-gassing emissions at the carpet between April 1994 and December 1993 is not readily evident from the published literature and or studies conducted by the rug manufacturers or their trade associations."). In fact, numerous published studies and industry documents consistently demonstrate that the actual rate of decline of emissions **[**51]** from carpet is nothing like a half-life progression. See, e.g., *id.* at A128, A145, A242, A248-250, A268-270, SA0860, SA0956, SA1020. Rather, emissions decline rapidly in the first hours and days after installation, reaching a level of about 10% of the original emission rate in only one week and as low as .05% of the initial emission rate in only one month. The differences between the emission rates indicated in these studies and those estimated by Todd's back-extrapolation theory are fairly substantial. (We express them graphically in the margin.¹⁶) For example, under Todd's theory, about ten days after installation of new carpet, VOCs would remain at levels approximately 50% of their initial level, while the studies in the record indicate that the levels would actually be less than 10% of their initial level. Within three weeks of installation, under Todd's theory, VOCs would be at 25% of their initial level, while the studies show that carpet, at this point, is emitting only about 1% of the initial amount of VOCs emitted at the time of installation. In short, the VOC levels estimated by Todd greatly exceed those which more likely existed, and follow a very different curve. **[**52]** Therefore, the District Court properly exercised its discretion to exclude this part of Todd's testimony.

Heller contends that even if Todd's "calculations were imprecise, it is undisputed that the level of VOC emissions in December 1993 were significantly higher than the VOC levels measured in April 1994." Appellants' Br. at 10 n.2. The problem with this argument, however, is that even if the levels were higher in December 1993, the calculations of plaintiff's expert were "imprecise" because his methodology was unreliable, and therefore Heller has presented no reliable evidence to demonstrate what the actual (or even reliably estimated) level of VOCs was in December 1993. Without a reliable method to determine how much higher the levels were in December 1993, only the actually measured levels in April 1994 are admissible evidence--and, as noted above, these levels were far too low to prove that the Shaw carpet was emitting harmful levels of VOCs.

There are other flaws in Todd's **[**53]** back-extrapolation testimony that also support the District Court's decision to exclude this testimony. **[*164]** First, Todd conflates emission rates and air concentration rates in his analysis. All of the record data on which Todd claims he relied to estimate his back-extrapolation formula involve the declining *emission rate*: VOCs are emitted at a certain rate at the time of carpet installation; by 24 hours later, they are emitted at approximately half this rate; by a week later, they are emitted at approximately 10% the original rate, etc. The *air concentration* of VOCs (which is what Todd measured in the closet in April and May 1994, and used as the starting point for his back-extrapolation) is a function of not only the rate at which VOCs are emitted from the carpet to the air, but also such factors as the rate at which VOCs dissipate in the air, the size of the room or house in which the VOCs are emitted, the molecular weight of the particular VOC, the rate of air flow, the moisture, light, and air temperature in the room, and other factors. See, e.g., John C. Little et al., *Modeling Emissions of Volatile Organic Compounds from New Carpets*, 28 Atmospheric Env't 227 (1994) **[**54]** (describing development of a model indicating that air concentration of a VOC is a function of time, distance from carpet, diffusion rate of the

¹⁶[SEE GRAPHS IN ORIGINAL]

VOC, carpet thickness, air flow rate, carpet and room area, and air volume). Therefore, to measure the *air concentration* at one point in time (as Todd did) and to attempt to estimate the *air concentration* four months earlier, one would need to know (or have a good estimate of) each of these factors, i.e., emission rates, room size, air flow, dissipation rate of each compound, etc.--none of which Todd considered in his back-extrapolation formula.

Second, there is at least one study in the record that appears to indicate that while *emission rates* of VOCs decline rapidly (see *supra* note 16), *air concentration* levels remain fairly constant after an initial slight increase, making Todd's conflation of these two factors even more problematic. See Alfred T. Hodgson et al., *Emissions of Volatile Organic Compounds from New Carpets Measured in a Large-Scale Environmental Chamber*, J. Air & Waste Mgmt. Ass'n, Mar. 1993, at 316, 323 (describing study indicating that emission rates of styrene and 4-phenylcyclohexene decline **[**55]** rapidly, while air concentration rates fluctuate within a relatively narrow range). Therefore, it is entirely plausible that the level of VOCs in the air was *not* much higher in December 1993 than the very low level measured in April 1994, the only time such VOCs were actually measured.

Finally, if one were to credit Todd's back-extrapolation theory, it would actually invalidate his closet studies, thereby eliminating the only basis for his opinion that the Shaw carpet was the source of the VOCs in the Heller home. This is because the decline in benzene and 2-butoxyethanol, two of the key VOCs on which plaintiff rests her case, could be explained almost entirely by the back-extrapolation theory, eliminating the possibility that it was the removal of the carpet that caused the levels of these VOCs to decline. Under Todd's back-extrapolation theory, the benzene would be expected to decline from 2.22 ppb on April 14, 1994, to approximately 0.40 ppb on May 11, 1994, even without the removal of the Shaw carpet; it actually declined to only 0.55 ppb. The 2-butoxyethanol would have been expected to decline from 5.6 ppb to approximately 1.0 ppb; it actually declined to 0.0 ppb, making **[**56]** the maximum amount attributable to the removed carpet only 1.0 ppb--substantially lower than the recommended limit of 20,000 ppb for this compound. The District Court noted this inconsistency, see *Heller*, 1997 WL 535163, at *12, as did Todd himself implicitly on cross-examination at the *Daubert* hearing, see App. at A543, A886.

3. Todd's Testimony: Summary and Conclusion

Although we believe that the District Court may have been overly critical of Todd's closet tests and that those aspects of its unreliability finding may have been inconsistent with the exercise of sound discretion, given the patent unreliability of Todd's back-extrapolation theory and the fact that the closet tests did not indicate levels of VOCs **[*165]** anywhere near the levels found to cause illnesses in humans, we hold that the District Court did not abuse its discretion in excluding all of Todd's testimony. Cf. *Paoli*, 35 F.3d at 749 n.19 (noting that all of an expert's testimony could be excluded as irrelevant if it no longer assists plaintiff's case after certain parts are excluded as unreliable).

IV. Summary Judgment

Without Dr. Papano's testimony on specific causation or Todd's testimony on **[**57]** the allegedly higher levels of VOCs in December 1993 (both of which we hold the District Court was correct to exclude), the remaining expert testimony and other evidence in the record are insufficient to create a material issue on causation. We note that the District Court granted summary judgment at least in part because "defendant's carpeting is not the obvious cause of plaintiffs' illnesses." *Heller*, 1997 WL 535163, at *18. This appears to place a more stringent burden on plaintiff than is warranted at summary judgment, but the District Court also relied on the total lack of causation evidence absent the expert testimony, which is a proper ground for summary judgment.

Certain of plaintiff's claims do not rely on the causal connection between Heller's illness and the Shaw carpet to survive. However, without Todd's testimony, plaintiff has failed to offer admissible proof that the Shaw carpet was defective. The only claim that does not require proof of either the causal connection or defectiveness is plaintiff's misrepresentation claim. We are satisfied, however, that the District Court properly granted summary judgment on this claim as well. See *id.* at *19 ("There is **[**58]** no evidence of record to support plaintiffs' assertion that they were injured by reliance on [Shaw's] alleged misrepresentation.").

The order of the District Court granting summary judgment to Shaw will be affirmed.

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