Clin Orthop Relat Res (2016) 474:1360–1369
DOI 10.1007/s11999-015-4623-0

Clinical Orthopaedics and Related Research®
A Publication of The Association of Bone and Joint Surgeons®

CLINICAL RESEARCH

# Do Orthopaedic Surgeons Acknowledge Uncertainty?

**Teun Teunis MD, Stein Janssen MD, Thierry G. Guitton MD, PhD, David Ring MD, PhD, Robert Parisien MD**

Received: 24 August 2015 / Accepted: 30 October 2015 / Published online: 9 November 2015


**Abstract**

*Background* Much of the decision-making in orthopaedics rests on uncertain evidence. Uncertainty is therefore part of our normal daily practice, and yet physician uncertainty regarding treatment could diminish patients' health. It is not known if physician uncertainty is a function of the evidence alone or if other factors are involved. With added experience, uncertainty could be expected to diminish, but perhaps more influential are things like physician confidence, belief in the veracity of what is published, and even one's religious beliefs. In addition, it is plausible that the kind of practice a physician works in can affect the experience of uncertainty. Practicing physicians may not be immediately aware of these effects on how uncertainty is experienced in their clinical decision-making.

*Questions/purposes* We asked: (1) Does uncertainty and overconfidence bias decrease with years of practice? (2) What sociodemographic factors are independently associated with less recognition of uncertainty, in particular belief in God or other deity or deities, and how is atheism associated with recognition of uncertainty? (3) Do confidence bias (confidence that one's skill is greater than it actually is), degree of trust in the orthopaedic evidence, and degree of statistical sophistication correlate independently with recognition of uncertainty?

*Methods* We created a survey to establish an overall recognition of uncertainty score (four questions), trust in the orthopaedic evidence base (four questions), confidence bias (three questions), and statistical understanding (six questions). Seven hundred six members of the Science of Variation Group, a collaboration that aims to study variation in the definition and treatment of human illness, were approached to complete our survey. This group represents

One of the authors (DR) certifies that he, or a member of his immediate family, has or may receive payments or benefits, an amount of less than USD 10,000 during the study period from Wright Medical (Memphis, TN, USA); an amount less than USD 10,000 from Skeletal Dynamics (Miami, FL, USA); an amount less than USD 10,000 from Biomet (Warsaw, IN, USA); an amount less than USD 10,000 from AO North America (Paoli, PA, USA); and an amount less than USD 10,000 from AO International (Dubendorf, Switzerland).
All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research*® editors and board members are on file with the publication and can be viewed on request.
This work was performed at the Massachusetts General Hospital–Harvard Medical School, Boston, MA, USA.

**Electronic supplementary material** The online version of this article (doi:10.1007/s11999-015-4623-0) contains supplementary material, which is available to authorized users.

T. Teunis
General Surgery, Onze Lieve Vrouwe Gasthuis, Amsterdam, The Netherlands

S. Janssen
Musculoskeletal Oncology Service, Massachusetts General Hospital–Harvard Medical School, Boston, MA, USA

T. G. Guitton
Orthopaedic Surgery, Academic Medical Center, Amsterdam, The Netherlands

D. Ring (✉)
Orthopaedic Hand and Upper Extremity Service, Massachusetts General Hospital–Harvard Medical School, 55 Fruit Street, Boston, MA 02114, USA
e-mail: dring@mgh.harvard.edu; dring@partners.org

R. Parisien
Orthopaedic Surgery, Elliot Hospital, Manchester, NH, USA

mainly orthopaedic surgeons specializing in trauma or hand and wrist surgery, practicing in Europe and North America, of whom the majority is involved in teaching. Approximately half of the group has more than 10 years of experience. Two hundred forty-two (34%) members completed the survey. We found no differences between responders and nonresponders. Each survey item measured its own trait better than any of the other traits. Recognition of uncertainty (0.70) and confidence bias (0.75) had relatively high Cronbach alpha levels, meaning that the questions making up these traits are closely related and probably measure the same construct. This was lower for statistical understanding (0.48) and trust in the orthopaedic evidence base (0.37). Subsequently, combining each trait's individual questions, we calculated a 0 to 10 score for each trait. The mean recognition of uncertainty score was 3.2 ± 1.4.

*Results* Recognition of uncertainty in daily practice did not vary by years in practice (0–5 years, 3.2 ± 1.3; 6–10 years, 2.9 ± 1.3; 11–20 years, 3.2 ± 1.4; 21–30 years, 3.3 ± 1.6 years; $p = 0.51$), but overconfidence bias did correlate with years in practice (0–5 years, 6.2 ± 1.4; 6–10 years, 7.1 ± 1.3; 11–20 years, 7.4 ± 1.4; 21–30 years, 7.1 ± 1.2 years; $p < 0.001$). Accounting for a potential interaction of variables using multivariable analysis, less recognition of uncertainty was independently but weakly associated with working in a multispecialty group compared with academic practice (β regression coefficient, −0.53; 95% confidence interval [CI], −1.0 to −0.055; partial $R^2$, 0.021; $p = 0.029$), belief in God or any other deity/deities (β, −0.57; 95% CI, −1.0 to −0.11; partial $R^2$, 0.026; $p = 0.015$), greater confidence bias (β, −0.26; 95% CI, −0.37 to −0.14; partial $R^2$, 0.084; $p < 0.001$), and greater trust in the orthopaedic evidence base (β, −0.16; 95% CI, −0.26 to −0.058; partial $R^2$, 0.040; $p = 0.002$). Better statistical understanding was independently, and more strongly, associated with greater recognition of uncertainty (β, 0.25; 95% CI, 0.17–0.34; partial $R^2$, 0.13; $p < 0.001$). Our full model accounted for 29% of the variability in recognition of uncertainty (adjusted $R^2$, 0.29).

*Conclusions* The relatively low levels of uncertainty among orthopaedic surgeons and confidence bias seem inconsistent with the paucity of definitive evidence. If patients want to be informed of the areas of uncertainty and surgeon-to-surgeon variation relevant to their care, it seems possible that a low recognition of uncertainty and surgeon confidence bias might hinder adequately informing patients, informed decisions, and consent. Moreover, limited recognition of uncertainty is associated with modifiable factors such as confidence bias, trust in orthopaedic evidence base, and statistical understanding. Perhaps improved statistical teaching in residency, journal clubs to improve the critique of evidence and awareness of bias, and acknowledgment of knowledge gaps at courses and conferences might create awareness about existing uncertainties.

*Level of Evidence* Level 1, prognostic study.

## Introduction

Much of the decision-making in orthopaedics rests on uncertain evidence. Well-designed randomized controlled trials frequently show no difference or a small and possibly unimportant differences between two treatments [8, 19]. *Clinical Evidence* [3] currently classifies 50% of 3000 common medical treatments as of "unknown effectiveness" and only 11% as proven beneficial (of the remainder 24% are likely to be beneficial, 7% a tradeoff between benefits and harms, 5% unlikely to be beneficial, and 3% likely to be ineffective or harmful). Although a dearth of evidence seems part of everyday practice, physician uncertainty regarding treatment could diminish patients' health, because many come to their provider for confident guidance. The degree to which providers perceive uncertainty about what is and is not actually known about matters relevant to everyday orthopaedic practice has not, to our knowledge, been measured.

As surgeons gain experience, it is plausible that what they previously considered to be uncertain becomes less so. Recognition of uncertainty could be influenced by many other personal factors as well. There are some reports suggesting religion [1, 21, 24] and overconfidence are important factors [7, 25, 26]. As evidence might replace uncertainty, confidence in, and understanding of, what is published might also influence the recognition of uncertainty.

We therefore asked: (1) Does uncertainty and overconfidence bias decrease with years of practice? (2) What sociodemographic factors are independently associated with less recognition of uncertainty, in particular belief in God or other deity or deities, and how is atheism associated with recognition of uncertainty? (3) Do overconfidence bias, degree of trust in the orthopaedic evidence, and degree of statistical sophistication correlate independently with recognition of uncertainty?

## Materials and Methods

### Study Design

We approached all 706 participants of the Science of Variation Group (SOVG; an international collaboration of upper extremity surgeons) to complete the survey on the

recognition of uncertainty of whom seven participants opted out from the SOVG (Appendix 1 [Supplemental material is available with the online version of CORR®.]). The SOVG is a collaboration that aims to study variation in the definition and treatment of human illness without financial incentives. The remaining 699 members represent mainly Western orthopaedic surgeons (86% [599] practice in Europe or North America), who are involved in teaching (80% [560]). Seventy percent specializes in orthopaedic traumatology (33% [229]) or hand and wrist surgery (37% [257]). Experience is relatively equally distributed, because half of the group has more than 10 years of experience (47% [329]). On joining, the SOVG participants gave approval to be approached for questionnaire studies. Participation in our study was optional; therefore, we did not acquire additional institutional review board approval. The first invitation was sent in the beginning of May 2015 and we sent reminders at 2 and 4 weeks.

## Questionnaire Development

The survey was developed by us after a collaborative discussion about how uncertainty is treated in daily clinical orthopaedics. Our aim was to evaluate factors that we predicted would be associated with more or less uncertainty. The selected questions were the more relevant and provocative of a much larger group that we chose from. The survey was then reviewed by the American Association for Hand Surgery Research Listserv, a collaboration of hand surgeons who help each other with the design of research protocols, without financial incentives. After baseline characteristics, four questions were used to establish an overall recognition of uncertainty score. Subsequently, four questions determined the level of trust in the orthopaedic evidence base and three questions determined the level of confidence bias (confidence that one's skill is greater than it actually is). Answers were provided on an ordinal scales; this way we could normalize final trait scores to a 0 to 10 score for comparison with 0 being the lowest and 10 being the highest possible score for each trait. Six multiple-choice questions gauged the respondent's level of statistical understanding. This trait was also scored on a 0 to 10 scale with 0 meaning no correct answers and 10 answering all six questions correctly. After completion of the study we analyzed item correlations in their domain (convergent validity) and with other domains (divergent validity). No items had higher divergent than convergent validity. This means each item measures predominantly its own domain and does not more accurately capture any of the other domains. We also measured the Cronbach alpha of each domain. This is a measure of internal consistency; in other words, how closely related a set of items are as a group. If items are more closely related, they probably measure the same construct. Recognition of uncertainty (0.70) and confidence bias (0.75) had relatively high Cronbach alpha levels. The alpha levels were lower for statistical understanding (0.48) and trust in the orthopaedic evidence base (0.37) (Table 1). The survey was concluded by four additional questions regarding uncertainty in daily practice, of which the final open question asked participants why their confidence changed with time. These answers were categorized by two investigators (TT, SJ). Consensus on the categories was reached by discussion after independently analyzing and assigning themes to a subset of 50 suggestions. After this consensus, both investigators (TT, SJ) analyzed the remaining suggestions. In the final analysis we grouped improved diagnostic, surgical, and communication skills under experience because those are expected to improve with practice. Statements similar to "knowledge of what works in my hands" were categorized as anecdotal outcomes. We made a distinction between statements similar to "acquiring more knowledge" and "learned that there is an absence of knowledge." Each participant's answer could pertain to three categories.

## Study Population

Of the 706 approached participants, 242 responded (34%). This does not represent a response rate per se, because many of the surgeons we email do not regularly participate, and the email addresses have not been confirmed. After excluding seven participants opting out from the SOVG, we found no difference in sex, practice years, or specialization between the remaining responders and nonresponders (n = 457). Responders were more likely to be European (nonresponders 23% [107 of 457] versus responders 37% [90 of 242], $p < 0.001$) and supervise trainees (nonresponders 76% [346 of 457] versus responders 88% [214 of 242] (Appendix 2 [Supplemental materials are available with the online version of CORR®.]).

Two hundred thirty-four (97%) completed the survey; incomplete surveys were excluded from multivariable analysis. Ninety-two percent (222) were men, and 51% (123) worked predominantly in academic practice. Approximately half (52% [126]) worked in North America followed by 37% (90) working in Europe. Sixty percent (146) were politically liberal or moderately liberal, and 32% (76) were conservative or very conservative. Sixty percent (146) believed in God, 8% (20) had no opinion, 17% (40) were agnostic, and 15% (36) were atheists. Only 8% (17) thought their confidence had decreased since graduate training (Table 2).

**Table 1.** Assessing convergent and divergent validity of individual items with the five domains of our questionnaire

| Domain | Uncertainty | Trust in the orthopaedic literature | Confidence bias | Statistical understanding | Cronbach alpha |
|---|---|---|---|---|---|
| Uncertainty | | | | | 0.70 |
| Item 1 | 0.84* | −0.19 | −0.31 | 0.30 | |
| Item 2 | 0.82* | −0.19 | −0.27 | 0.34 | |
| Item 3 | 0.74* | −0.18 | −0.26 | 0.29 | |
| Item 4 | 0.41* | 0.12 | −0.11 | 0.080 | |
| Trust in the orthopaedic literature | | | | | 0.37 |
| Item 1 | −0.31 | 0.61* | 0.15 | −0.10 | |
| Item 2 | 0.023 | 0.64* | −0.049 | 0.18 | |
| Item 3 | 0.029 | 0.71* | −0.087 | 0.16 | |
| Item 4 | −0.21 | 0.32* | −0.0047 | −0.12 | |
| Confidence bias | | | | | 0.75 |
| Item 1 | −0.25 | 0.019 | 0.89* | −0.16 | |
| Item 2 | −0.30 | 0.034 | 0.90* | −0.13 | |
| Item 3 | −0.29 | −0.062 | 0.63* | −0.19 | |
| Statistical understanding | | | | | 0.48 |
| Item 1 | 0.23 | 0.078 | −0.090 | 0.62* | |
| Item 2 | 0.059 | −0.0064 | 0.072 | 0.46* | |
| Item 3 | 0.28 | 0.059 | −0.19 | 0.54* | |
| Item 4 | 0.27 | 0.11 | −0.15 | 0.59* | |
| Item 5 | 0.14 | 0.065 | −0.20 | 0.35* | |
| Item 6 | 0.19 | −0.045 | −0.047 | 0.60* | |

* Correlation of the item with own domain (convergent validity); numbers without asterisk indicate correlation of the item with other domains (divergent validity); no items had higher divergent than convergent validity.

### Statistical Analysis

We used frequencies to describe discrete variables; continuous variables are reported as means and SDs. For statistical analysis we grouped separately the affirming and disaffirming answers to "do you believe in God, any other deity/deities?" and "would you consider yourself a religious person?"

Fisher's exact test was used to determine the differences between categorical variables. Unpaired Student's t-test and one-way analysis of variance were used to determine the differences between continuous and dichotomous variables and Pearson correlations were used for two continuous variables (Table 3). All variables with $p < 0.10$ on explanatory bivariate analysis were entered in a multivariable linear regression model. We regarded a two-tailed p value $< 0.05$ to be significant.

A priori power analysis indicated that 185 participants would provide 0.80 power to detect a variable explaining 3% of the variability in recognition of uncertainty, assuming our full model with five predictors would explain 30% of the variability and alpha set at 0.05.

## Results

Recognition of uncertainty in daily practice did not vary by years in practice (0–5 years, 3.2 ± 1.3; 6–10 years, 2.9 ± 1.3; 11–20 years, 3.2 ± 1.4; 21–30 years, 3.3 ± 1.6 years; $p = 0.51$) (Table 3); however, confidence bias did increase by years of practice (0–5 years, 6.2 ± 1.4; 6–10 years, 7.1 ± 1.3; 11–20 years, 7.4 ± 1.4; 21–30 years, 7.1 ± 1.2; $p < 0.001$). To the question of how confidence changed after graduate training, the majority who answered "decreased" were in the 21 to 30 years of practice group (0–5 years, 5% [four of 83]; 6–10 years, 6% [three of 53]; 11–20 years, 6% [four of 73]; 21–30 years, 19% [six of 33]; $p = 0.038$) (Appendix 3 [Supplemental material is available with the online version of CORR®.]). Of all participants, the majority stated that their current level of confidence was reached because of increased experience (58% [173 of 297]) and more knowledge (20% [58 of 297]) (Fig. 1). When assessing only the 21 statements of participants whose confidence had decreased, 43% (nine of 21) ascribed this to recognizing the limits of the orthopaedic evidence base (Fig. 2).

**Table 2.** Participants' demographics and other questions.

| Demographics | Value |
|---|---|
| Participants | 242 |
| Men | 92% (222) |
| Years in practice | |
| 0–5 | 34% (83) |
| 6–10 | 22% (53) |
| 11–20 | 30% (73) |
| 21–30 | 14% (33) |
| Geographic location | |
| North America | 52% (126) |
| Europe | 37% (90) |
| Other | 11% (26) |
| Specialization | |
| General orthopaedics | 4.6% (11) |
| Orthopaedic traumatology | 37% (89) |
| Shoulder and elbow | 16% (39) |
| Hand and wrist | 36% (86) |
| Other | 7% (17) |
| Practice type | |
| Academic | 51% (123) |
| Multispecialty group | 13% (31) |
| Large private practice, 10 or more providers | 12% (30) |
| Small private practice, less than 10 providers | 5.4% (13) |
| Hospital-employed practice | 19% (45) |
| Supervise trainees | 88% (214) |
| Perceived risk of litigation | |
| Very low | 14% (35) |
| Low | 39% (95) |
| Neutral | 23% (56) |
| High | 19% (47) |
| Very high | 3.7% (9) |
| Hours a month spent keeping up with published research | 13 ± 10 |
| Political orientation | |
| Very liberal | 27% (66) |
| Moderately liberal | 33% (80) |
| Libertarian | 8.3% (20) |
| Moderately conservative | 17% (40) |
| Very conservative | 15% (36) |
| Do you believe in God, any other deity/deities? | |
| Yes, God is a major force in my life | 27% (66) |
| Yes, but I do not practice religion often | 33% (80) |
| No opinion | 8.3% (20) |
| No, but I consider myself an agnostic rather than an atheist | 17% (40) |
| No, I am an atheist | 15% (36) |
| Would you consider yourself a religious person? | |
| Yes, and I worship regularly | 20% (49) |
| Yes, but I do not worship regularly | 25% (61) |
| Moderately, or I do not really think about it | 13% (32) |
| No, not really, but I do not rule it out | 26% (62) |
| Not at all, I am an atheist (I believe there is no God) | 16% (38) |
| Uncertainty | 3.2 ± 1.4 |
| Trust in the orthopaedic literature | 4.4 ± 1.5 |
| Confidence bias | 6.9 ± 1.4 |
| Statistical understanding | 3.6 ± 1.9 |
| Other questions | |
| You are confronted with an uncertain situation, perhaps a decision to operate or treat nonoperatively, where both choices seem reasonable and the decision is difficult; your response to a patient asking you a question about how the outcome would be different between the two is (pick your most typical response): | |
| I do not know which treatment is best | 22% (49) |
| I am not entirely sure, and I am going to try to look this up | 13% (30) |
| We, in the medical community, do not know the answer to that some things are just not known | 40% (90) |
| I make a guess based on what is most probable, because patients do not respond well to uncertainty, and my role is to not only treat to the best of my ability, but to provide reassurance | 19% (43) |
| This does not happen often enough to me in my field of specialty practice for me to have a typical response; most of what I do is quite certain and well studied | 4.9% (11) |
| When it comes to decisions that are uncertain and without an established consensus, I make a decision based on (pick the best): | |
| My experience | 54% (121) |
| What the least invasive choice is | 13% (30) |
| What the patient wants | 23% (51) |
| What I think the medical community would most accept | 7.2% (16) |
| What I am feeling at the time | 2.2% (5) |
| How has your confidence changed since you graduated training? | |
| Decreased | 7.6% (17) |
| Unchanged | 7.2% (16) |
| Increased | 85% (190) |

Continuous variables = mean (± SD); discrete variables = percentage (number); some questions and answers have been abbreviated, for the exact survey, see Appendix 1.

After accounting for a potential interaction of confounding variables, we found that working in a multispecialty group, compared with academic practice, was weakly associated with less recognition of uncertainty (β regression coefficient, −0.53; 95% confidence interval [CI], −1.0 to −0.055; partial $R^2$, 0.021; p = 0.029).

Belief in God or any other deity or deities also was weakly associated with less recognition of uncertainty (β, −0.57; 95% CI, −1.0 to −0.11; partial $R^2$, 0.026; p = 0.015). Additional analysis showed statistical understanding, belief in God, and regarding oneself to be a religious person to be associated (multicollinear). On excluding those variables, we found that being an atheist was

**Table 3.** Uncertainty and explanatory variables

| Explanatory variables | Uncertainty | p value |
|---|---|---|
| Sex | | |
| Women | 2.9 ± 0.90 | 0.46 |
| Men | 3.2 ± 1.4 | |
| Years in practice | | |
| 0–5 | 3.2 ± 1.3 | 0.51 |
| 6–10 | 2.9 ± 1.3 | |
| 11–20 | 3.2 ± 1.4 | |
| 21–30 | 3.3 ± 1.6 | |
| Geographic location | | |
| North America | 3.3 ± 1.3 | 0.31 |
| Europe | 3.1 ± 1.4 | |
| Other | 2.9 ± 1.7 | |
| Specialization | | |
| General orthopaedics | 3.1 ± 1.1 | 0.93 |
| Orthopaedic traumatology | 3.2 ± 1.4 | |
| Shoulder and elbow | 3.2 ± 1.4 | |
| Hand and wrist | 3.1 ± 1.3 | |
| Other | 3.4 ± 1.8 | |
| Practice type | | |
| Academic | 3.4 ± 1.4 | 0.011* |
| Multispecialty group | 2.6 ± 1.3 | |
| Large private practice, 10 or more providers | 2.8 ± 1.3 | |
| Small private practice, less than 10 providers | 2.7 ± 1.2 | |
| Hospital-employed practice | 3.3 ± 1.4 | |
| Supervise trainees | | |
| Yes | 3.1 ± 1.4 | 0.37 |
| No | 3.4 ± 1.3 | |
| Perceived risk of litigation | | |
| Very low | 2.9 ± 1.4 | 0.16 |
| Low | 3.1 ± 1.4 | |
| Neutral | 3.5 ± 1.5 | |
| High | 3.0 ± 1.3 | |
| Very high | 3.1 ± 1.1 | |
| Hours a month spent on keeping up with published research | −0.015 | 0.81 |
| Political orientation | | |
| Very liberal | 3.3 ± 1.4 | 0.22 |
| Moderately liberal | 3.3 ± 1.4 | |
| Libertarian | 3.5 ± 1.5 | |
| Moderately conservative | 2.9 ± 1.3 | |
| Very conservative | 2.9 ± 1.0 | |
| Do you believe in God, any other deity/deities? | | |
| Yes | 2.9 ± 1.3 | 0.0023* |
| No | 3.5 ± 1.4 | |
| Would you consider yourself a religious person? | | |
| Yes | 3.0 ± 1.3 | 0.098 |
| No | 3.3 ± 1.4 | |
| Trust in the orthopaedic literature | −0.17 | 0.0087* |
| Confidence bias | −0.34 | < 0.001* |
| Statistical understanding | 0.36 | < 0.001* |
| You are confronted with an uncertain situation, perhaps a decision to operate or treat nonoperatively, where both choices seem reasonable and the decision is difficult; your response to a patient asking you a question about how the outcome would be different between the two is (pick your most typical response): | | |
| I do not know which treatment is best | 3.5 ± 1.7 | 0.0091* |
| I am not entirely sure, and I am going to try to look this up | 2.8 ± 1.2 | |
| We, in the medical community, don't know the answer to that; some things are just not known | 3.2 ± 1.3 | |
| I make a guess based on what is most probable, because patients do not respond well to uncertainty, and my role is to not only treat to the best of my ability, but to provide reassurance | 3.3 ± 1.4 | |
| This does not happen often enough to me in my field of specialty practice for me to have a typical response; most of what I do is quite certain and well studied | 2.0 ± 0.66 | |
| When it comes to decisions that are uncertain and without an established consensus, I make a decision based on (pick the best): | | |
| My experience | 2.9 ± 1.4 | 0.063 |
| What the least invasive choice is | 3.1 ± 1.4 | |
| What the patient wants | 3.5 ± 1.4 | |
| What I think the medical community would most accept | 2.9 ± 1.4 | |
| What I am feeling at the time | 4.4 ± 1.7 | |
| How has your confidence changed since you graduated training? | | |
| Decreased | 4.0 ± 1.5 | 0.025* |
| Unchanged | 3.4 ± 1.5 | |
| Increased | 3.0 ± 1.4 | |

Continuous variables as mean (± SD); discrete variables as percentage (number); *statistical significance, $p < 0.05$; some questions and answers have been abbreviated; for the exact survey, see Appendix 1.

independently, weakly associated with greater recognition of uncertainty (β, 0.65; 95% CI, 0.20–1.11; partial $R^2$, 0.035; p= 0.005) (Appendix 4 [Supplemental material is available with the online version of CORR®.]).

Greater confidence bias was somewhat correlated with less recognition of uncertainty (β, −0.26; 95% CI, −0.37 to −0.14; partial $R^2$, 0.084; $p < 0.001$).

Greater trust in the orthopaedic evidence base also was weakly correlated with less recognition of uncertainty (β, −0.16; 95% CI, −0.26 to −0.058; partial $R^2$, 0.040; p = 0.002).

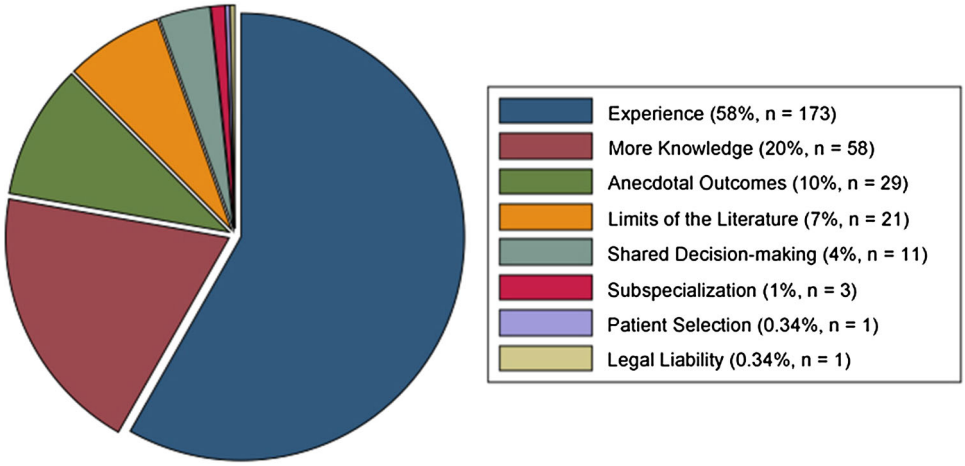


**Fig. 1** Participants provided 297 reasons for their current confidence level. These were categorized into eight groups.

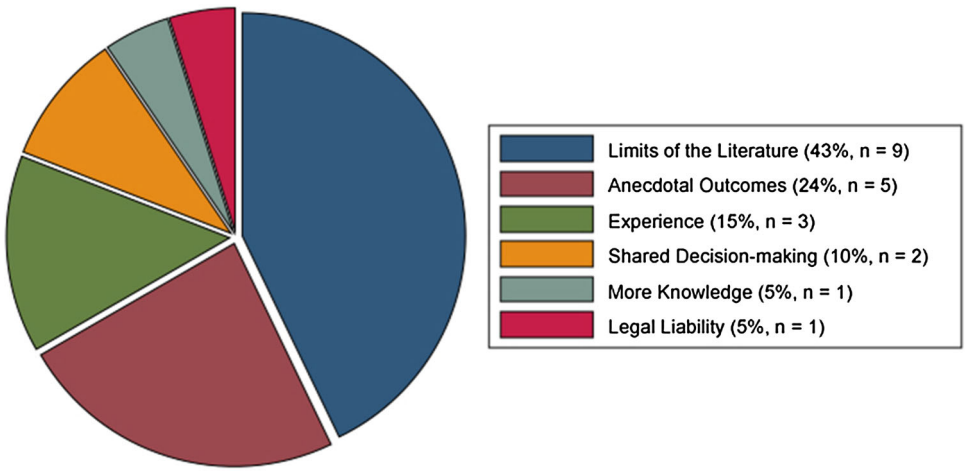


**Fig. 2** Participants with decreased confidence provided 21 reasons for this.

**Table 4.** Multivariable analysis of factors associated with greater uncertainty

| Uncertainty | Regression coefficient (95% CI) | Standard error | p value | Partial $R^2$ | Adjusted $R^2$ |
|---|---|---|---|---|---|
| Practice type | | | | | 0.29 |
| Academic | Reference value | | | | |
| Multispecialty group | −0.53 (−1.0 to −0.055) | 0.24 | 0.029* | 0.021 | |
| Large private practice, 10 or more providers | −0.32 (−0.80 to 0.17) | 0.25 | 0.20 | | |
| Small private practice, less than 10 providers | −0.30 (−1.0 to 0.41) | 0.36 | 0.41 | | |
| Hospital-employed practice | −0.077 (−0.50 to 0.34) | 0.21 | 0.72 | | |
| Believing in God, any other deity/deities | −0.57 (−1.0 to −0.11) | 0.23 | 0.015* | 0.026 | |
| Considering yourself to be a religious person | 0.28 (−0.18 to 0.73) | 0.23 | 0.23 | | |
| Trust in the orthopaedic literature | −0.16 (−0.26 to −0.058) | 0.052 | 0.002* | 0.040 | |
| Confidence bias | −0.26 (−0.37 to −0.14) | 0.056 | < 0.001* | 0.084 | |
| Statistical understanding | 0.25 (0.17–0.34) | 0.044 | < 0.001* | 0.13 | |

Only the partial $R^2$ of significant values are shown; *statistical significance, $p < 0.05$; CI = confidence interval.

Better statistical understanding was more strongly correlated with greater recognition of uncertainty (β, 0.25; 95% CI, 0.17–0.34; partial $R^2$, 0.13; $p < 0.001$).

Our full model accounted for 29% of the variability in recognition of uncertainty (adjusted $R^2$, 0.29) (Table 4).

## Discussion

A lack of evidence seems to be part of everyday practice, affecting approximately 50% of common conditions in medicine [3]. Physician uncertainty regarding treatment may adversely affect patients' health. The aim of our study was to evaluate the acknowledgment of uncertainty by orthopaedic surgeons and to establish factors that might affect how surgeons regard uncertainty in daily orthopaedic practice. Working in a multispecialty group, belief in God or any other deity or deities, greater confidence bias, and greater trust in the orthopaedic evidence base were weakly associated with less recognition of uncertainty. Greater statistical understanding was more strongly associated with greater recognition of uncertainty.

This study has some limitations. First, surgeons of the SOVG are a subgroup in the community of orthopaedic surgeons. They represent Western orthopaedic surgeons of whom the majority supervises trainees. Using them as study subjects may have resulted in selection bias, because non-Western orthopaedic surgeons, or surgeons not involved in teaching, are not represented. This limits the generalizability of our results. Second, only 34% of the SOVG members filled out our survey. This is not a response rate per se, because many of the surgeons we email do not regularly participate, and the email addresses have not been confirmed. Also, we found no gross difference between responders and nonresponders. Third, when we gauged the reliability of our nonvalidated survey, we found that each survey item measured its own trait better than any of the other traits. Also recognition of uncertainty and confidence bias had relatively high Cronbach alpha levels; in other words, the questions making up these traits are closely related and probably measure the same construct. However, this was lower for statistical understanding and trust in the orthopaedic evidence base. There is no benchmark score for recognition of uncertainty, trust in the orthopaedic evidence base, confidence bias, and statistical understanding in the orthopaedic literature. Interpretation of these scores is a matter of preferences and values until evidence suggests that specific opinions or attitudes are beneficial.

The degree to which surgeons regard uncertainty does not seem to change with greater experience. We found a pervasive overconfidence bias (confidence that one's skill is greater than it actually is) among orthopaedic surgeons, because 83% of the group considered themselves to be above average diagnosticians, and none regarded themselves as below average. Similarly, 74% of our group regarded themselves as above average surgeons and 25% regarded themselves as being in the top 5%. Although it is possible that this is accurate—maybe the surgeons in this study group are above average—this seems more likely attributable to overconfidence bias. There is evidence that confidence and accuracy are at odds in medicine. For example, radiologists who performed less well were highly confident that they were accurate [20]; a survey of 100 internal medicine physicians found only a very small difference in confidence in diagnostic accuracy between very difficult and simple clinical cases, whereas there was a large difference in actual diagnostic accuracy [16], and surgical residents were confident they would recognize different distal radius fractures 68% of the time while actually identifying only 33% correctly [18]. Overconfidence bias can lead to other biases such as the availability heuristic (considering only the first thing that comes to mind) and confirmation bias, where a person notices only the things that agree with his or her point of view and is less attentive to support for alternative viewpoints [15]. Limiting confirmation bias in medical decision-making requires an effort to seek disconfirming evidence, a characteristic of type 2 (analytical, reflective, slow) rather than type 1 (fast, intuitive, heuristic) thinking disposition [7, 25, 26]. Uncertainty-intolerant physicians might be less likely to use analytical thinking, contributing to their sense of overconfidence.

Surgeons working in academic centers had the greatest awareness of uncertainty, especially compared with those working in multispecialty groups. This might be because academicians are more exposed to teaching, writing papers, and complex cases and as such might be more likely to be required to identify the foundations in evidence that underlie their propositions. In that search, they may develop a more acute awareness of the many gaps in our shared knowledge base [3, 17].

One of the more interesting findings in our study was that we found that theists (believers in God or another deity) showed less recognition of uncertainty in daily orthopaedic practice. Conversely, being an atheist was independently associated with greater recognition of uncertainty. The effect of theistic belief on uncertainty was as strong as the other effects we studied. Although at first glance a physician's personal view on God and religion might seem to be irrelevant to how medical evidence is regarded, our data suggest that an association may exist. A plausible explanation could be that the highly theistic desire certainty and that desire is fulfilled with their belief and that same desire for certainty could carry over to a desire for certainty in medical decision-making. There are some reports supporting the contention that intolerance of uncertainty is a quality of people who are highly religious [1, 21, 24]. There are also abundant explanations given in the popular literature relating theism to certainty [4, 5]. Furthermore, it is argued that believers are more likely to see uncertainty as a failure of knowledge rather than as an intrinsic fact of the world [9]. On these views, theism as a

denial of uncertainty is in contradistinction to a view in which truth is only approximated and all knowledge and theories are subject to revision based on additional evidence.

Greater confidence bias was correlated with less uncertainty. Orthopaedic surgeons in this study group showed a confidence bias, which seems discordant with the paucity of available evidence. The way surgeons process areas of debate and uncertainty can affect their justification for medical decisions and recommendations. A study describing factors influencing recommendations for surgery in scenarios where evidence for a optimal treatment is limited found that justifications such as "works in my hands" and "familiarity with the treatment" are prevalent [12]. The Dartmouth Atlas [23] showed rates of procedures that are associated with more uncertainty vary more than procedures that have more evidential support in the literature. Physicians, and surgeons in particular may naturally have difficulty with uncertainty because of the need to satisfy patient questions and because many patients find confidence comforting. Patients likely would prefer and probably ethically should be aware of the boundaries of medicine's knowledge as part of informed decision-making. For this to happen physicians need to be aware of and should be able to concisely articulate these boundaries to patients with various levels of health literacy. Balanced and dispassionate patient information tools such as decision aids might help surgeons inform their patients. Previous authors reported that expressing uncertainty does not diminish patient satisfaction [11], and patients provided with decision aids often are more satisfied with their care [22].

Greater trust in the orthopaedic evidence base was associated with less uncertainty. To some, trust in the orthopaedic evidence base may fulfill a role in health care similar to that of religion in everyday life. Published studies serve as an anchor to reduce some of the experienced uncertainty. However, a large part of what is published may not be true [14], and even highly cited studies often are refuted with time [13]. Having unwaivering faith in the orthopaedic evidence therefore is not warranted and a healthy skepticism seems a more appropriate attitude, something journal clubs on how to critique the literature might help to achieve.

We found greater recognition of uncertainty in those who scored higher on statistical sophistication. Conceivably, subjects who are more versed in statistical understanding also are more exposed to the concept of uncertainty. However, even among subjects who are more cognizant of uncertainty, the overall level of statistical understanding was low, a finding commonly noted in other studies [2, 6, 27]. Physicians' lack of understanding of health statistics is thought by some to be one of the major impediments to healthcare efficiency [10]. Differences in tolerance for uncertainty and deficient understanding of statistics might have measurable effects on care. For example, those less tolerant of uncertainty may be more inclined to order more diagnostic tests, raising costs, but also unwittingly introducing more false-positive and -negative results. The added uncertainty that each test brings might lead to erroneous decisions. Future research might address this possibility.

Our data suggest the possibility that intrinsic and extrinsic factors outside our immediate awareness may affect how surgeons regard uncertainty. Our aim is to draw attention to this and to show that there are variations in how aware we are of the prevalence of uncertainty in our daily lives as surgeons. Recognition of our tolerance or intolerance of uncertainty can influence how we communicate with our patients. A deficiency in recognizing uncertainty and a propensity toward overconfidence might impede adequate informed consent and incorporation of patients' preferences. Furthermore, this intolerance of uncertainty could lead to ordering more diagnostic tests, thereby raising costs and increasing the risk of unhelpful treatments, a thesis that merits additional study. Perhaps improved statistical teaching in residency, journal clubs to improve the critique of evidence and awareness of bias, and acknowledgment of knowledge gaps at courses and conferences might create awareness about existing uncertainties.

## References


1. Abramowitz JS, Deacon BJ, Woods CM, Tolin DF. Association between Protestant religiosity and obsessive-compulsive symptoms and cognitions. *Depress Anxiety.* 2004;20:70–76.
2. Berwick DM, Fineberg HV, Weinstein MC. When doctors meet numbers. *Am J Med.* 1981;71:991–998.
3. Clinical Evidence. What conclusions has Clinical Evidence drawn about what works, what doesn't based on randomised controlled trial evidence? BMJ Publishing Group Limited. Available at: http://clinicalevidence.bmj.com/x/set/static/cms/efficacy-categorisations.html. Accessed May 7, 2014.
4. Dawkins R. *The God Delusion.* New York, NY, USA: Bantam Books; 2006.
5. Dennett D. *Breaking the Spell: Religion as a Natural Phenomenon.* New York, NY, USA: Penguin; 2006.
6. Estellat C, Faisy C, Colombet I, Chatellier G, Burnand B, Durieux P. French academic physicians had a poor knowledge of terms used in clinical epidemiology. *J Clin Epidemiol.* 2006;59:1009–1014.
7. Evans JSB. In two minds: dual-process accounts of reasoning. *Trends in Cognitive Sciences.* 2003;7:454–459.
8. Gibbs L, Gambrill E. Evidence-based practice: counterarguments to objections. *Res Social Work Prac.* 2002;12:452–476.
9. Gigerenzer G. Smart Heuristics. In: Brockman J, ed. *Thinking: The New Science of Decision Making, Problem Solving, and Prediction in Life and Markets.* New York, NY, USA: Harper Collins; 2013.
10. Gigerenzer G, Muir Gray JA. *Better Doctors, Better Patients, Better Decisions: Envisioning Healthcare in 2020.* Cambridge, MA, USA: MIT Press; 2011.

11. Gordon GH, Joos SK, Byrne J. Physician expressions of uncertainty during patient encounters. *Patient Educ Couns.* 2000;40:59–65.
12. Hageman MG, Guitton TG, Ring D, Science of Variation Group. How surgeons make decisions when the evidence is inconclusive. *J Hand Surg Am.* 2013;38:1202–1208.
13. Ioannidis JP. Contradicted and initially stronger effects in highly cited clinical research. *JAMA.* 2005;294:218–228.
14. Ioannidis JP. Why most published research findings are false. *PLoS Med.* 2005;2:e124.
15. Kahneman D. *Thinking, Fast and Slow*. New York, NY, USA: Macmillan; 2011.
16. Meyer AN, Payne VL, Meeks DW, Rao R, Singh H. Physicians' diagnostic accuracy, confidence, and resource requests: a vignette study. *JAMA Intern Med.* 2013;173:1952–1958.
17. National Guideline. American Academy of Orthopaedic Surgeons clinical practice guideline 2010. Agency for Healthcare Research and Quality (AHRQ). Available at: http://www.guideline.gov/index.aspx. Accessed May 5, 2014.
18. Oskam J, Kingma J, Klasen HJ. Clinicians' recognition of 10 different types of distal radial fractures. *Percept Mot Skills.* 2000;91:917–924.
19. Pawson R. Evidence based policy: in search of a method. *Evaluation.* 2002;8:157–181.
20. Potchen EJ. Measuring observer performance in chest radiology: some experiences. *J Am Coll Radiol.* 2006;3:423–432.
21. Schaefer R. Uncertainty and the limits of culture. *Journal of Religion & Society.* 2015;17.
22. Stacey D, Legare F, Col NF, Bennett CL, Barry MJ, Eden KB, Holmes-Rovner M, Llewellyn-Thomas H, Lyddiatt A, Thomson R, Trevena L, Wu JH. Decision aids for people facing health treatment or screening decisions. *Cochrane Database Syst Rev.* 2014;1:CD001431.
23. The Dartmouth Institute of Health Policy and Clinical Practice. The Dartmouth atlas of healthcare. 2014. The Dartmouth Institute of Health Policy and Clinical Practice. Available at: http://www.dartmouthatlas.org/. Accessed February 26, 2014.
24. Thouless RH. The tendency to certainty in religious belief. *British Journal of Psychology. General Section.* 1935;26:16–31.
25. Tversky A, Kahneman D. Judgment under uncertainty: heuristics and biases. *Science.* 1974;185:1124–1131.
26. Wason P, Evans JSB. Dual processes in reasoning? *Cognition.* 1975;3:141–154.
27. Wulff HR, Andersen B, Brandenhoff P, Guttler F. What do doctors know about statistics? *Stat Med.* 1987;6:3–10.