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Profiling quality of care: Is there a role for peer review?

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Abstract

Background: We sought to develop a more reliable structured implicit chart review instrument for use in assessing the quality of care for chronic disease and to examine if ratings are more reliable for conditions in which the evidence base for practice is more developed.

Methods: We conducted a reliability study in a cohort with patient records including both outpatient and inpatient care as the objects of measurement. We developed a structured implicit review instrument to assess the quality of care over one year of treatment. 12 reviewers conducted a total of 496 reviews of 70 patient records selected from 26 VA clinical sites in two regions of the country. Each patient had between one and four conditions specified as having a highly developed evidence base (diabetes and hypertension) or a less developed evidence base (chronic obstructive pulmonary disease or a collection of acute conditions). Multilevel analysis that accounts for the nested and cross-classified structure of the data was used to estimate the signal and noise components of the measurement of quality and the reliability of implicit review.

Results: For COPD and a collection of acute conditions the reliability of a single physician review was quite low (intra-class correlation = 0.16–0.26) but comparable to most previously published estimates for the use of this method in inpatient settings. However, for diabetes and hypertension the reliability is significantly higher at 0.46. The higher reliability is a result of the reviewers collectively being able to distinguish more differences in the quality of care between patients ($p < 0.007$) and not due to less random noise or individual reviewer bias in the measurement. For these conditions the level of true quality (i.e. the rating of quality of care that would result from the full population of physician reviewers reviewing a record) varied from poor to good across patients.

Conclusions: For conditions with a well-developed quality of care evidence base, such as hypertension and diabetes, a single structured implicit review to assess the quality of care over a period of time is moderately reliable. This method could be a reasonable complement or alternative to explicit indicator approaches for assessing and comparing quality of care. Structured implicit review, like explicit quality measures, must be used more cautiously for illnesses for which the evidence base is less well developed, such as COPD and acute, short-course illnesses.

Background

Assessing the quality of health care for populations of patients over time is a major challenge facing health systems and health insurers [1,2]. Increasingly, quality measurement for such populations focuses on chronic illnesses and is carried out using explicit, or pre-set, review criteria or indicators. The widely used indicators approach to quality assessment (e.g., Health Plan Employer Data and Information Set HEDIS 2000) addresses chronic disease management for an ever-growing number of chronic diseases such as hypertension, diabetes, and depression [3]. For a variety of reasons, however, explicit indicators have not entirely replaced the other principle method for assessing quality of care, implicit peer review, throughout the healthcare, regulatory and legal system.

Implicit peer review relies on expert judgment of the quality of care for an individual patient case. In its most rigorous implementation, structured implicit review (SIR) has been an important tool for measuring quality of care in research [4-13]. Implicit review, as carried out by Medicare Peer Review Organizations, was widely used to try to prevent abuse arising from application of prospective payment for hospitals [14]. While Medicare and the Peer Review Organizations have increasingly emphasized explicit process measures over implicit record review by physicians [15,16], there is still nearly universal use of implicit review by hospitals and physician groups in credentialing and determining clinical privileges [17,18]. A form of implicit peer review by expert physicians is the only method of assessing standard of care consistently used in malpractice litigation.

The continued use of implicit review is most likely due to the ease of development and administration of the method, its face validity, and its ability to self-update through use of current experts, to reflect the full scope of clinical decisions that may apply to a particular patient, and to involve physicians in the quality of care process. These are areas in which explicit indicators such as HEDIS can be criticized for falling short. Of concern, however, is the well-documented low reliability of peer review methods, particularly those that are unstructured, and the lack of testing of the method for review in the outpatient setting, where the majority of care is delivered for chronic illnesses.

The estimated reliability for the measurement of overall quality of care in the published literature, even when using SIR, is generally poor, in the range of 0.2 to 0.3 [6,9,12,13,19,20] with two studies citing reliability of 0.5 [5,7]. Even more variable estimates of reliability are obtained for rating specific components of care or other settings of care [10,11,21,22]. One source of variation in reliability estimates is the numerous methods employed

for quantifying reliability. Most studies of implicit review report simple kappa statistics or correlations and none consider the cross-classified nature of the data (a review is nested within patients crossed with reviewer). Most ignore the tendency for some reviewers to consistently judge more harshly or leniently than other reviewers. When studies do consider these reviewer effects, they estimate them in a way that does not readily allow the reliability findings to be generalizable to other reviewer populations (by using fixed instead of random effects in the analysis) [23,24]. Finally, few published reliability studies examine how reliability is affected by diagnosis or care delivered over an extended period of time. Understanding the conditions under which implicit review functions well may be critical to improving the capabilities and use of the method.

This study evaluates structured implicit review of outpatient and inpatient care over a one year period for a population of patients by evaluating care for three chronic illnesses and for rapid onset, short course acute illnesses. We developed a new structured implicit review instrument drawing on previously tested instruments [5,10,20]. We selected reviewers well versed in evidence based principles of practice and trained them to emphasize evidence-based care in their reviews. We addressed limitations of previous studies in two ways. First we tested the effects on implicit review of the quantity and quality of the evidence base for a condition by comparing review reliability for two conditions (diabetes, hypertension) for which the quality of care evidence base is substantial to two others for which it is limited (COPD, acute illnesses). Second we evaluated the relative importance of several sources of variability in implicit reviews using generalizability theory (an extension of classical test theory) [25]. With these techniques, extraneous sources of variation can be identified and potentially removed, leading to significant improvement in the measurement properties of implicit review.

Methods

Study sample and data collection

As part of a larger study, we sampled veterans who had at least two outpatient visits for each of two years in clinics offering primary care from eleven health systems in two regions, one in the Midwest and one in the West. We over sampled three target conditions (diabetes, hypertension, and COPD). We requested medical records for each patient for a two-year time period from October 1, 1997 to September 30, 1999. For this study, we selected 70 cases from the full sample of 621 cases selected for the larger study using stratified random sampling, oversampling for the three target chronic disease conditions. Reviewers then used implicit review to evaluate care given over a

thirteen-month period: September 1, 1998 to September 30, 1999.

Reviewer selection and training

Selection of reviewers

Reviewers were required to be trained, board certified internists (American Board of Internal Medicine) with current or recent general or internal medicine outpatient experience and to be conversant with principles of evidence-based medicine. This latter qualification was assessed through the use of a screening questionnaire and discussions with one or more clinicians listed as references by the applicants for the reviewer positions [see Additional file 1]. All were one or more years beyond residency. Although primarily in academic positions, they worked in a variety of practice settings and two different geographic locations. They were solicited by flyer, email and word of mouth. Only one had previously done quality related record reviews and none was a professional reviewer.

Description of the training

Each reviewer completed sixteen hours of training. The reviewers were instructed to imagine that, for each case reviewed, the patient was a new patient in their practice and coming with the documentation of the last 1–2 years of their care. For each of the conditions they were asked to assess the diagnosis and assessment of the initial presentation of the condition (if it occurred during this period), assessment and monitoring the course of the condition,

treatment of signs or symptoms, exacerbations or complications, and follow-up. They were then asked to provide an assessment of the quality of care. In providing this assessment they were to consider how the care compares to what would be provided in a typical US community practice with respect to appropriateness, timeliness and quantity. In particular was the care appropriate, or was there overuse, misuse, or underuse? They were further to consider the importance of any overuse, underuse, or misuse. That is, if care was not completely appropriate, they were asked to consider whether the problems were likely to result in worse outcomes for a typical patient with the medical problem. They were instructed to focus on the process of care, and links supporting causal connections between processes and outcomes, and not the outcomes themselves. Then they rated the overall quality of care on a six-point scale.

Review process

Reviews took place in Ann Arbor and Los Angeles over a 6 month period from October 2001 to March 2002. The reliability sub-study took part within the larger job of reviewing the 621 charts from the parent study. Reviewers were unaware of which records were chosen for the reliability analyses. During the review, reviewers were able to scan available records prior to the study period (October 1, 1997 to August 31, 1998), but were instructed that their review should focus on care provided during the study period.

Design

Table 1: Mean ratings and distribution of reviews across conditions

Reviewer	HTN [‡]	COPD [§]	Diabetes	Acute Care	Total	Mean rating (s.d)
A	11	9	8	12	40	3.28 (1.11)
B	15	12	8	10	45	3.13 (1.20)
C	14	7	9	11	41	3.15 (1.37)
D	13	9	9	12	43	3.58 (1.61)
E	11	9	7	12	39	3.33 (0.58)
F	12	8	11	10	41	2.24 (1.18)
G	10	8	9	9	36	3.78 (1.29)
H	10	8	8	8	34	3.15 (0.93)
I	14	10	12	6	42	3.26 (0.91)
J	17	10	9	17	53	3.40 (0.77)
K	12	8	8	9	37	3.38 (0.59)
L	14	7	9	15	45	3.29 (1.38)
Total	153	105	107	131	496	
# unique records †	56	40	37	59	70	
Mean rating (s.d)*	3.46(1.20)	3.09(0.96)	3.46(1.30)	2.94(1.07)		3.25 (1.16)

*Ratings are on a 1–6 scale where 1 = very good care and 6=very poor care. † Each patient record may have been reviewed for more than one condition. Thus 56 out of the 70 total records were reviewed for the quality of hypertension care. A total of 153 reviews of the 56 different patient records were done by 12 different reviewers. ‡ Hypertension § Chronic obstructive pulmonary disease

The reliability study consisted of 12 physicians reviewing 70 patient records. Each patient record may have been reviewed for more than one condition. For example, 56 out of the 70 total records were reviewed for the quality of hypertension care and 59 were reviewed for acute care. For each patient record, three out of the 12 physician reviewers filled out between one and four condition specific instruments giving a total of 496 reviews over the whole sample. Assignment of reviewers to cases was random but stratified to balance each reviewer's appearance across the conditions and condition combinations. Three different reviewers reviewed each of the 70 cases. Table 1 shows the distribution of patients, conditions and reviews.

Data analysis

Our one pre-specified hypothesis was that the reliability of physician review, as measured by the intraclass correlations, would be significantly larger for the hypertension and diabetes quality ratings than for the COPD and acute conditions. Our model simultaneously examines reliability across the four separate domains of hypertension, COPD, diabetes and acute care management in a MANOVA style analysis. The model also accounts for the clustering of multiple reviews and multiple conditions within patient and the fact that each reviewer reviewed overlapping subsets of the 70 patients. We used a cross-classified, random effects model implemented in MLwiN. This analysis assumes that the rating data are normally distributed which appears warranted by the distribution plots illustrated in Figure 1. Details of the estimation method and model selection are described in the Appendix.

The analysis provides us with the variability of the true quality rating across patients, the variability in how each reviewer rates quality and the variability contributed by the undifferentiated noise in the measurement. The intraclass correlation (ICC) we report is the variability of the true quality rating divided by the total variability in the ratings (or the sum of all three sources of variability). The ICC can be interpreted as the proportion of variance that is due to the true differences in quality across patients. However, it is also the correlation between ratings that would be expected when two random reviewers rate the same record, and thus, it describes the reliability of a single review by a single randomly selected reviewer. (see the appendix for further details about calculating ICCs).

Results

Distribution of reviews and mean ratings

The distribution of reviews across conditions and reviewers is shown in Table 1. Reviewers were represented fairly evenly across conditions, reviewing between 7 and 17 cases each. There was considerable overlap of conditions across patients with most records being evaluated for

more than 1 condition. 12 records were evaluated for all four conditions, 31 records had three conditions, 24 records had 2 conditions and 3 records had only one of the four conditions. Thus while there are 70 total unique records, for each condition there are between 37 and 59 unique records that were reviewed.

The mean overall rating was 3.25 on a 1 to 6 scale, with a score of 1 assigned for very good care and a score of 6 assigned for very poor care. The reviewers used the entire six point scale given, with the distribution of ratings by condition shown in Figure 1. Table 1 also suggests differences in the mean ratings by reviewer and by condition.

Regression model

The results of the analysis using the full model are shown in Table 2. Variation at the patient level represents the true score differences in physician assessed quality of care across patient records in regard to the management of a particular condition. The true score is the rating that would be obtained from an infinitely large number of reviews and reviewers who were drawn from the population represented by our sample of reviewers. Variation at the reviewer level represents the idiosyncratic differences in opinions between physician reviewers and the extent to which some reviewers may have systematically higher or lower ratings than other reviewers across all records for a given condition. Variation at the review occasion level (repeated measurements of the same record) is termed "noise." It can be thought of as a reflection of the difficulty of the evaluation task. If it is hard to say whether the care provided is good or not, then there will be more noise. The relative size of the variance components for the true score, reviewer and noise are shown graphically in Figure 2.

We found that the true score variation (variance) in quality of care at the patient level for hypertension was 0.75 (thus the true score standard deviation is $\sqrt{0.75} = 0.87$, see Table 2). Consequently, we would predict that if reviewer ratings were averaged over a large population of reviewers similar to ours, 95% of the ratings would fall within 1.7 units (two standard deviations) in either direction of the average rating of 3.4 found for hypertension. That represents a range that is between poor and good and provides evidence that, even after accounting for the measurement error of this instrument, there are important differences in the quality of hypertension care. There is a comparable amount of variation due to noise (0.72) and a relatively small amount of variation due to systematic differences across patients by reviewer in their assessment of quality (0.15) indicating good agreement in the standards applied by the reviewers. The reliability of a single review for detecting differences in quality of hypertension care across patients is 0.46. Averaging as few as 5 reviews

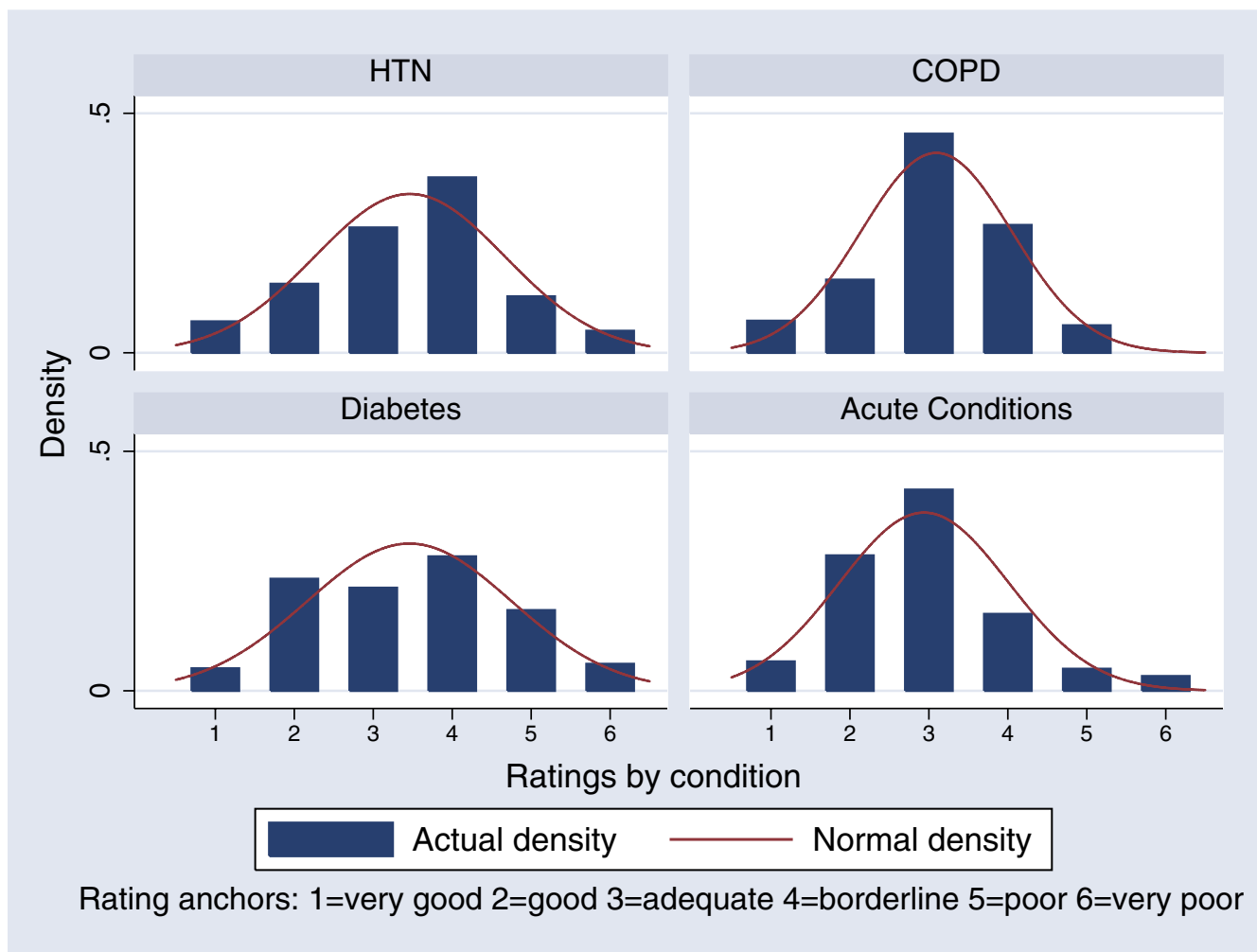


Figure 1
Distribution of quality ratings by condition This figure illustrates the distribution of ratings by condition for all the reviews done for that condition. Thus there are multiple observations per patient. The fact that ratings are clustered by reviewer and patient is not accounted for in this figure. The entire scale was used for each condition. A normal density for the observed mean and standard deviation is superimposed on the histogram of the actual distribution of ratings. The conditions are hypertension (HTN), diabetes, chronic obstructive pulmonary disease (COPD), and acute conditions.

of a single patient record would allow you to produce a rating of the quality of hypertension management for that patient with a reliability of 0.80, a level generally felt to be adequate for making decisions based on a measure [26]. The diabetes care evaluation works in very similar ways to the hypertension one discussed above (Table 2).

On the other hand, the structured implicit review of COPD care produced a true quality rating with a smaller variance of 0.30 (s.d. .55). This implies that 95% of patients with this condition experience care whose quality is rated between good and borderline. When the range of quality is narrow it becomes less clinically interesting to

try to search for reasons for the differences in quality across patients or to profile providers. While the noise component is also smaller when compared to the hypertension ratings, implying that the evaluation problem is not inherently more difficult, it shrank less than the true quality differences. Thus the reliability of a single review (true score variance over the total variance) is much smaller at 0.26 and over twice as many reviews would be required to generate a reliable quality measure for the management of COPD for a patient (12 reviews for a reliability of 0.80).

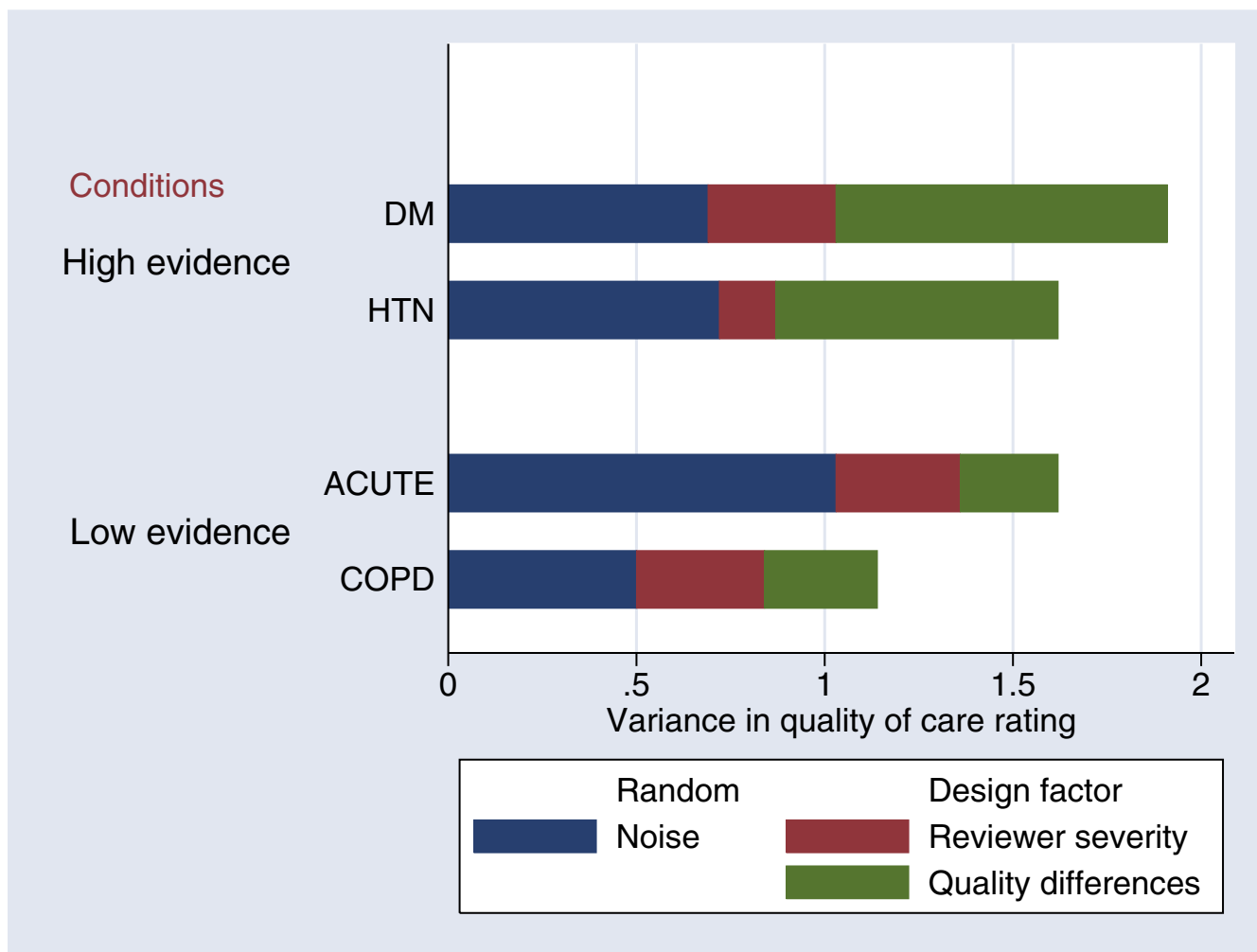


Figure 2
Variance components of medical record review The sources of variability in physician assessments of quality of care based on reviews of the medical record are shown here, stratified by the levels of evidence available for decision-making. The much larger amounts of signal or true quality differences in reviews of the high evidence conditions will produce measurements that are more reliable. For the low evidence conditions, the noise component is quite large for the reviews of acute conditions and the reviewer components are relatively large for both the acute and COPD conditions. The conditions are hypertension (HTN), diabetes mellitus (DM), chronic obstructive pulmonary disease (COPD), and acute conditions.

There is also less detectable systematic difference in the true quality of acute care management across patients (variance 0.26) than for diabetes or hypertension. In addition there is a substantially larger amount of random noise (1.03). Overall, the reliability of a single review is 0.16 making the instrument much less practical for the purpose of estimating the quality of care in a panel of patients (requiring 30 reviews to achieve a reliability of 0.80). Furthermore, the idiosyncratic evaluations of acute care management of the individual reviewers vary more widely (reviewer variance = 0.33) than the aspects of acute

care management that they can agree upon (true score patient variance = 0.26).

The estimation techniques we used allowed us to produce an empirical confidence interval for the reliability of each instrument (shown in Figure 3). As per our primary hypothesis, the hypertension and diabetes instruments taken together were significantly more reliable than the COPD and acute care instruments as shown by the non-overlapping confidence intervals. Furthermore, the patient level variance components for diabetes and hypertension were significantly larger than those for COPD and

Table 2: Sources of variation and reliability of quality assessments by physician implicit review

	HTN	COPD	Diabetes	Acute
Mean rating (1 – 6) *	3.41	3.09	3.39	2.90
Variance §				
Reviewer	0.15	0.34	0.34	0.33
Patient (between record)	0.75	0.30	0.88	0.26
Noise (within record)	0.72	0.50	0.69	1.03
Total variance	1.62	1.14	1.90	1.62
Proportion of total variance †				
Reviewer‡	0.09	0.30	0.18	0.20
Patient (between record)	0.46	0.26	0.46	0.16
Noise (within record)	0.44	0.44	0.36	0.64
Correlation of quality ratings at patient level				
COPD	0.382			
Diabetes	0.767	0.106		
Acute	0.359	0.314	0.262	

*Ratings are on a 1–6 scale where 1 = very good care and 6=very poor care. This is the rating for the average patient accounting for differences in reviewer severity. † Other than rounding error, the proportion of total variance sums to 100 across the 3 components. ‡ The proportion of variance at the patient level represents the reliability of structured implicit review for detecting differences between patients when assessed for samples of patients from a similar population and assessed by reviewers drawn from a population of similar reviewers. § Variation at the patient level represents the true score differences in physician ratings of quality of care across patients in regard to the specified condition. Variation at the reviewer level represents the idiosyncratic differences in rating severity the between physician reviewers. Variation at the review occasion level (repeated measurements of the same record) is termed "noise."

acute conditions (Wald chi squared test 3.62, $p < 0.007$) suggesting that the improved reliability is largely a result of the reviewers being able to distinguish a greater difference in the quality of care across the diabetes and hypertension patients.

The correlations between the ratings of quality of disease management are also shown in Table 2. The patient ratings of diabetes and hypertension are correlated fairly highly at 0.77 as might be expected given that there is considerable overlap in the indicated processes of care for the two conditions. The correlations between all other pairs of ratings are in the low to modest range 0.11–0.38, indicating that there is different information about disease management that is being evaluated for the different disease management domains. These correlations are corrected for any attenuation that would occur due to the measurement error in the instruments and represent the correlations between the 'true' ratings (as defined above).

Discussion

There are a number of important conclusions that one can draw from this work. First, we have shown that using structured implicit review it is possible to obtain ratings of the management of chronic diseases over an extended period of time and settings of care and that these ratings can have reasonably high reliability. Second, as we hypothesized, those conditions for which the evidence base is most developed, diabetes and hypertension, were the ones in which we were able to achieve the highest lev-

els of reliability. Third, the analytic approach that we espouse offers an important advance in assessing quality measurement tools by allowing us to draw substantive conclusions about how and for which conditions to attempt to measure quality of care using structured implicit review.

Using structured implicit review for evaluation of the continuum of care

Most physician peer review is done in hospitalized patients. While there is a recent RAND publication describing an outpatient implicit review instrument [27], there are no peer-reviewed published reliability studies of instruments used outside of the hospital setting and no structured implicit review instruments designed to measure quality across the continuum of care (over time and including inpatient and outpatient care). Yet to measure chronic disease care in particular, with its long-term objectives and multiple providers, this is the frame of interest.

For diabetes and hypertension, we achieved reliability measures that are as high as any published and that reflect an instrument that could produce a reliable estimate of the quality of disease management for a particular patient with as few as 5 record reviews. It is important to remember that the reliability of an instrument for distinguishing between patients does not tell us the reliability of using average scores across patients to distinguish between sites or physicians [28]. While we know that patient satisfaction and a number of individual quality measures have

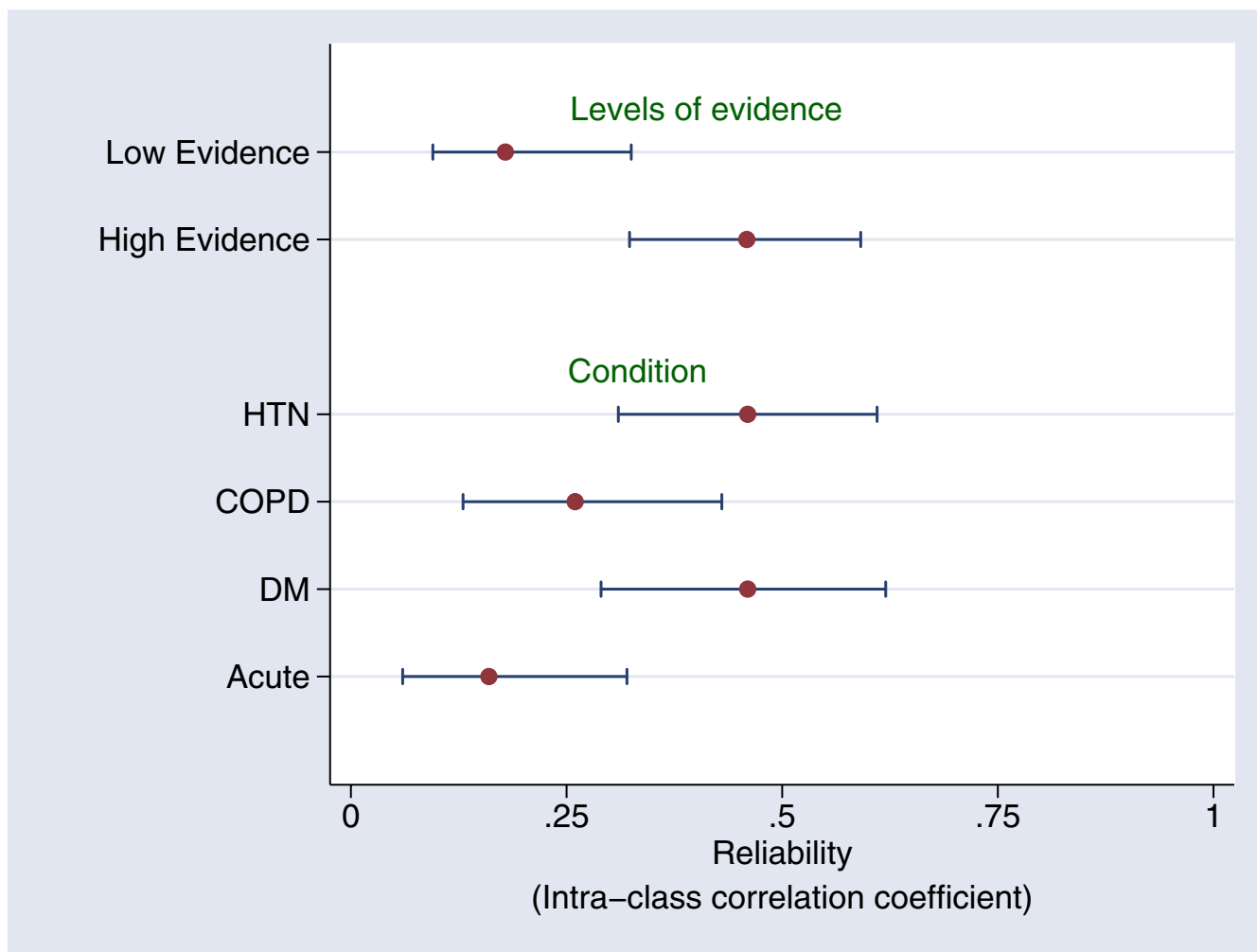


Figure 3
Reliability of a single physician review of a patient record for detecting quality differences This figure presents the reliability (intraclass correlation coefficients) of a single implicit review for detecting differences in true quality across patients. At the top, the conditions with a more developed or high evidence base (diabetes and hypertension) are compared to those with a less developed or low evidence base (COPD and acute conditions). At the bottom, the reliability for each of four conditions is presented with the empirical 95% confidence interval limits. The conditions are hypertension (HTN), diabetes mellitus (DM), chronic obstructive pulmonary disease (COPD), and acute conditions.

quite low reliabilities at the physician level [28-30], no study has reported a reliability for the use of the structured implicit review instrument in physician profiling. To estimate how many patients would be required to produce reliable physician or site quality estimates, we would need to assess the variability across another dimension, the site of care or the provider.

Nevertheless, we can say that if the true differences between physicians or sites of care, averaged across their patients, are on the same order as that seen across patients in this study (that is ranging from poor to good), then a

relatively small sample of 5-10 reviews would be sufficient to characterize the care for that site of care for conditions with a good evidence base for practice. Of course if the range of average ratings for physicians or sites of care is much smaller (e.g. clustered around "adequate-good" care) then the reliability for distinguishing between sites of care or providers will be much less, and a larger sample would be required. However, if all of the care is at a similar level across sites, then distinguishing between them becomes much less important [28].

While it is somewhat paradoxical that the reliability of a quality measure decreases as care increasingly conforms to a similar standard, it makes perfect sense that it is harder to distinguish small differences between providers or patients than it is to distinguish large differences. In fact this is extremely useful information to have. It can tell the profilers when they should describe the quality of care by the overall mean rather than bothering to generate provider specific measures.

When we consider the cost and difficulty of implementing explicit indicator approaches to quality assessment [31,32], implicit review instruments with this level of reliability become an interesting alternative for assessing quality of care for the purposes of comparing across providers or sites of care.

Increased evidence base improves the consistency of evaluation

Apart from coronary artery disease, diabetes and hypertension are two of the diseases with the largest number of published randomized clinical trials supporting the use of specific interventions to reduce significantly the mortality and morbidity associated with these conditions. A Medline search with the condition as major heading restricted to randomized controlled trials and no date restriction, reveals 2028 and 5275 randomized controlled trials within diabetes and hypertension respectively and 65 for COPD. Thus it is intriguing that the instruments measuring the quality of care for these conditions had the highest reliability while the COPD instrument had a lower reliability, reflecting a smaller component of variance attributable to differences in quality perceived systematically across all the reviewers.

It should not be surprising that physician implicit review works best for those conditions where the evidence base is best developed, just as these are the areas where explicit checklist forms of quality measurement are easiest to develop. Implicit physician review would have been a particularly useful tool if it could fill in the gap for assessment of conditions where the evidence base is less well developed, however, our study does not support this use. Even so, there may well be settings where implicit review is a more feasible approach than explicit measures and it might be desirable to use a combination of explicit and implicit methods, as they are complementary in many of their strengths and weaknesses. Furthermore, if a suitable sample of physician reviewers is selected, this type of reliability study can quantify the degree of uncertainty that exists among expert physicians about the standards of care for a particular disease management area. It can be very useful to know that we should not attempt to profile care for a condition because even a group of experts does not

have a very clear or consistent sense of whether care was appropriate in any given situation.

An analytic framework for evaluating quality measurement instruments

Generalizability theory is an appealing theoretical framework to use when trying to define and improve the measurement characteristics of an instrument [25]. Using the techniques employed here for partitioning the source of variability in ratings of quality of care, investigators have previously examined whether discussion of a case between reviewers can improve the reliability of structured implicit reviews. They found that it only provided a mirage of increased agreement, without any improvement in the reliability of the true score ratings [33]. Another study that evaluated quality of care at community based care organizations for the elderly (PACE centers) with a modified structured implicit review instrument, was the first to assess the contribution of different sources of variation to the measurement of quality by physician review. However, there were only 6 physician reviewers, hospital records were excluded and the instrument failed to identify any systematic variation in overall quality across patients (reliability of 0) for physician reviews [10].

Using this analytic approach, we found the most interesting differences across conditions are in the variance components that estimate the true quality differences found across patients and the difficulty of the review task (or noise component, see Figure 2). As is suggested by the relatively small differences in the quality component between patients for COPD, it may well be that the poor reliability of peer review in some settings is simply the result of the lack of information on which to base systematic practice. In other cases, as suggested by our results for the acute care instrument, the decision task seems particularly difficult, as reflected by the larger noise component. A better definition of the condition to be assessed or better training techniques might be able to reduce this component and improve the reliability of the instrument.

With the information generated by this type of analysis it is possible to define the optimal number of patients per provider or site and the number of reviews per patient necessary to produce a reliable measure for the level of comparison (provider or site) that is desired. While not commonly done, it is certainly possible to have more than one physician reviewer per record in an operational quality measurement system that sampled records from sites to monitor quality of care using implicit review. It is the possibility of designing more efficient measurement procedures that is the greatest potential contribution of this approach.

Conclusions

For evaluation of diabetes or hypertension care, a structured implicit review instrument would seem to be a viable alternative or complement to explicit indicator methods of assessing quality of care. There may be many cases where this may be a less expensive method to use, particularly where explicit indicator measures require extensive information technology modifications. The degree to which implicit review is more comprehensive and able to take into account the subtleties of care may make it more palatable to physicians. It may provide a counterweight to the tendency to teach to the test with specific indicator approaches [31]. Together, where the two methods are correlated, an assessment might be able to both reflect the individual nature of health care through implicit peer judgments and provide information about specific failed processes of care from an explicit indicator approach. It may be time to use structured implicit review more widely outside of research settings to assess quality of care.

Appendix

Estimation of the parameters was carried out by Bayesian methods, specifically a Markov Chain Monte Carlo (MCMC) method (MLwiN version 1.2). We specified non-informative priors and chain length was set to 500,000, sampling one out of every twenty iterations to minimize autocorrelation. In all models this was enough to reduce the Monte Carlo simulation error so that the estimate of each variance component was accurate to within 2 significant figures and the 95% coverage estimate was within 1% of the nominal 95% coverage interval [34].

The full model design has review occasion clustered by patient record, cross-classified with reviewer. Estimated parameters include a constant representing the mean rating; as well as variance estimates for the reviewer, patient record and review occasion for each of the four domains (hypertension, diabetes, COPD and acute care management). Model fit was estimated by examining the DIC (deviance information criterion) and the patterns of residuals.

The DIC was 2383 for the full model. However, the pattern of residuals at the reviewer level (and indeed the marginal ratings shown in Table 1) suggested that reviewer F was a potential outlier having the lowest score in three of the four domains. Thus a model was fit with the ratings of reviewer F estimated as a fixed effect. The DIC was 2425 representing worse fit. However, more importantly, the relative magnitude of the patient record variation and the noise variation was unchanged. Thus all results are presented for the full model.

Calculating reliability with an ICC

Several ICCs or reliabilities can be calculated when using this type of analysis. First, the most useful measure when considering the use of this instrument in other settings is the correlation of ratings between reviews of the same patient by two randomly selected reviewers and is calculated as

$$\sigma^2_{\text{patient}} / (\sigma^2_{\text{patient}} + \sigma^2_{\text{reviewer}} + \sigma^2_{\text{noise}}). \quad (\text{Eq. 1})$$

The correlation between reviews of the same patient by the same reviewer is

$$(\sigma^2_{\text{patient}} + \sigma^2_{\text{reviewer}}) / (\sigma^2_{\text{patient}} + \sigma^2_{\text{reviewer}} + \sigma^2_{\text{noise}}) \quad (\text{Eq. 2})$$

and is naturally higher, and is analogous to running all your measurements with the same instrument to reduce measurement error. However it does not reflect a particularly useful measurement strategy (one reviewer can not review all records). If an entity wished to use this instrument and was able to do a similar analysis to this current one for its sample of reviewers, it could estimate and remove their specific reviewer effects (which are extraneous noise to the primary purpose of detecting patient differences) and improve the reliability of the measurement. In this case, without the reviewer variation, the reliability is

$$\sigma^2_{\text{patient}} / (\sigma^2_{\text{patient}} + \sigma^2_{\text{noise}}). \quad (\text{Eq. 3})$$

We report reliability based on Eq. 1 described above but this method of analysis allows one to compute whichever reliability measure is appropriate for a particular set of measurement conditions.

A much more commonly used measure of reliability in this setting is the kappa coefficient. In the case of two reviewers this data could be analysed for agreement of the 1–6 score assigned by each reviewer. The weighted kappa is mathematically equivalent to the ICC as calculated by equation 3 in the case of two raters when the weight is $\{(i-j)/(k-1)\}^2$ (where i and j index the ratings by the two raters and k is the number of categories) [35]. The ICC analysis can accommodate the more complex designs commonly used in these reliability studies and provides a much richer description by identifying the various contributions to the lack of agreement.

Competing interests

None declared.

Authors' contributions

TPH drafted the manuscript, performed the statistical analysis and participated in the design. SMA conceived of the study, and participated in its design, analysis and coor-

dination. RAH participated in the design, analysis and manuscript preparation. LVR participated in the design, and manuscript preparation. MMH supervised the data collection and data management, and participated in the design, coordination and analysis. JA participated in the design and statistical analysis. EAK conceived of the study, and participated in its design, analysis and coordination

Additional material

Additional File 1

Implicit Reviewer Recruitment and Selection. A brief description of the reviewer recruitment process and a list of the screening questions for the reviewer applicants and those listed as clinical references.

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