Coming full circle in the measurement of medication adherence: opportunities and implications for health care

Abstract: There is little debate that medication nonadherence is a major public health issue and that measuring nonadherence is a crucial step toward improving it. Moreover, while measuring adherence is becoming both more feasible and more common in the era of electronic information, the reliability and usefulness of various measurements of adherence have not been well established. This paper outlines the most commonly used measures of adherence and discusses the advantages and disadvantages of each that depend on the purpose for which the measure will be used. International consensus statements on definitions and guidelines for selection and use of medication adherence measures were reviewed. The quality of recommended measures was evaluated in selected publications from 2009 to 2014. The most robust medication adherence measures are often ill suited for large-scale use. Less robust measures were found to be commonly misapplied and subsequently misinterpreted in population-level analyses. Adherence assessment and measurement were rarely integrated into standard patient care practice patterns. Successful scalable and impactful strategies to improve medication adherence will depend on understanding how to efficiently and effectively measure adherence.

Keywords: adherence measures, medication adherence, study design, patient-reported outcomes, research methods

Introduction

Poor medication adherence is a burgeoning public health issue, the management of which is limited by our inability to accurately measure it. Though measuring adherence is becoming more feasible and more common in the era of electronic information, the selection of the most appropriate measure remains largely a matter of convenience and ease of data access. Similar to the convenience sampling, convenience-based measurement introduces bias and data quality error that pose a risk for interpretation and threaten the apt use of findings for policy and practice.

In this era of big data, we have become both enabled and obsessed with measurement and analytics in the context of medication use. From prescription order to fill date, pick-up, and refill, we measure frequency, accuracy, omissions, and errors. We forget, however, that “how” and “when” we measure is as important as “what” we measure. In the business of health care, decisions informed by incomplete or inaccurate measurement pose risk far beyond unprofitability. Arguably, in no other sector is the need for appropriate measurement so crucial as it is in health care — and the cost of inaccuracy so potentially injurious. And yet, many of the practices and standard metrics for medication adherence implemented at the bedside or at the pharmacy counter have
been developed to address the economics of health care, and
often by stakeholders who lack a sophisticated understand-
ing of the medication counseling experience, the patient
experience, or the intricacies of clinical data. Furthermore,
existing published research does not yet provide a basis for
the formulation of clear use case guidelines. Accordingly,
all one can currently do is to better understand the purpose
and utility of each measurement type and select a metric that
most closely aligns with the desired outcome.

The metrics for medication adherence, flagged as a major
cost driver,2–4 and a focus of reform,5,6 have become the
focus of a frenzy of activity associated with understanding
and affecting medication-related health care spending in the
US. This is understandable, given the proportion of gross
domestic product spent on health care, increasing from 4.4%
in 1950 to 17.9% in 2012.7,8 Yet, the enormity of the issue of
medication nonadherence extends well beyond the immediate
health care market, with overall medication-related losses to
the US economy estimated at $317 billion.9 With the advent
of health care reform, medication nonadherence quickly
emerges as a front running opportunity for improvement.
The opportunity, however, is complex – with the need to
evaluate and compare large-scale health systems and profit
centers juxtaposed against the need to improve patient-level
medication-taking behavior. This commentary outlines cur-
cent measures of adherence, discusses advantages and disad-
vantages of various approaches, and provides clear examples
of well-suited uses relative to the practices of pharmacists,
clinicians, payers, and researchers. In addition, limitations
in current measures of medication adherence and persist-
ence are highlighted to increase awareness and to improve
the accuracy of appropriate selection of adherence metrics
according to research design and study purpose. Ultimately,
successful strategies to improve medication adherence on
a large scale will depend on improving the efficiency and
effectiveness of adherence measures that benefit patients,
practitioners, payers, and policy makers. Given the import,
further research is needed to establish and validate clear use
cases for the myriad of measurement metrics available.

Measurement challenges
The push to improve medication adherence has resulted in
a surfeit of data generated by pharmacy claims that, when
used haphazardly, is neither quantitatively or qualitatively
advantageous. For example, claims data can effectively
be harnessed to evaluate efficiency in dispensing systems,
 gauge improvement in productivity and refill trends and
identify “best practices” across plans, physicians, and
pharmacists – but this type of measurement has limitations
when used for medication therapy management (MTM)
and selection of patient-level interventions. The limitation
for use of claims data in practice is the wide range of data
discrepancy and the variations in precursors to poor adher-
ance. In fact, appropriate patient-level interventions are often
dependent upon changes in social support or daily routines
in the home; factors that are not components of calculated
medication possession ratio (MPR) or other usual adherence
calculations in claims-based data.10,11

Similar challenges exist in the context of clinical treat-
ment. For example, direct measures used in controlled
research may have limited usefulness for practice, where
the pressures of time constraints and limited resources may
render the choice of direct measurement, such as pill counts,
unreasonable. Likewise, accurate pharmacokinetic measures
(such as International Normalized Ratio measures for warfa-
in effect) are available for only a few medications and where
available, associated measurement techniques may be too
intrusive and costly to administer. Finally, while dispensing
records, bioavailability markers, and pill counts may assist
with building a picture of each patient’s adherence over time,
they will not ultimately yield the type of data necessary to
assess adherence at a specific point in time and may not be
useful for continuous routine monitoring – data that pharma-
cists and clinicians often rely upon in their day-to-day prac-
tice. Accordingly, those who measure adherence – or evaluate
existing research results for decision-making purposes – must
pay particular attention to both the value and limitations of
the array of measurement metrics available.

Matching the hammer to the nail –
purposeful measurement
In the absence of a “gold standard” of adherence measure-
ment, the choice of metric must take into account the purpose
of each individual assessment. This decision must consider
the potential usefulness and reliability of the data in light of
the user and recognize that some methods are appropriate
only for certain situations. For example, if the user is a payer,
researcher, physician, or pharmacist, the metric selected must
reliably measure the goals of that user (e.g., reimbursement,
comparisons of effectiveness, clinical treatment, or medica-
tion counseling, respectively).

The existing body of literature provides little guidance on
how best to match measurement metrics with appropriate use.
Rigorous research and in-depth review has been identified as
a critical limiting factor to the development of much needed
adherence-informed tools for health care professionals.12,13
Relevant published literature broadly assigns methods for measuring adherence into two categories, direct and indirect, based upon mode of observation employed by each. To begin to distinguish relative value among many measures, Table 1 describes both direct and indirect measures and denotes advantages for each. Optimal metric selection depends on the type of adherence being assessed, the precision required, and the intended use of the results. For example, while measurement of medication adherence rates at the population level through consistent use of calculations based on pharmacy claims data has value, population-based measures provide minimal information about the individual. Appreciation of the strengths and limitations of each measure may prevent negative consequences, both at the patient level, such as over-prescribing in resistant hypertension, and the policy level, such as imprecise empirical justification of payment bundling.

“Robust” measures are characterized as measures that have the potential to yield the type and amount of data necessary for understanding comprehensive patterns of daily adherence. For this purpose, the best measures may include direct or indirect assessment of the patient’s medication-taking behavior, clinical response to therapy, and/or related physiological markers, such as the concentrations of drug or metabolite in blood or urine, or detection or measurement in blood of a biologic marker added to the drug formulation. As valuable as these measures can be in clinical practice, they can often be predictive but not conclusive. Complicating factors can give a false impression of real-life adherence behavior. For example, unobserved and unmeasured individual traits may be related to both the explanatory variable and the outcome being examined. This problem, known as “endogeneity,” is found to obscure and confound the relationship between medication adherence, health services utilization measures such as readmission rates, and cost.

Of all robust measures, face-to-face observation of medication taking, or direct observation therapy, provides the most accurate point in time evaluation data and can facilitate even richer insight through provider–patient engagement. However, the limitations to the utility of this method are obvious – and the realistic value of this measure outside of an inpatient or research setting is limited to the family caregiver. Other direct methods, such as measurement of drug or metabolite levels in blood or urine, or detection of blood-levels of biological markers added to the drug formulation, prove drug ingestion and are thus very reliable estimates of medication adherence. They are, however, less robust in that they are subject to bias from variations in metabolism and “white coat adherence,” and can give a false impression of real-life adherence behavior. In addition, they are expensive and complex to administer, are not available for the majority of medications, and on a population basis, they may not be scalable or feasible. Accordingly, these direct measures of adherence are largely reserved for the clinical trial setting or situations such as tuberculosis or HIV, where exigent circumstances justify the means.

Measures that use an identified proxy event (such as package opening) to evaluate medication-taking behavior can also be robust when the proxy event is closely related to the ingestion or application of the medication. Technological advances in indirect adherence measurement including digital pills, technology-equipped packaging, and Medication Event Monitoring Systems (MEMS) use proxy events ranging from package opening to actual pill ingestion to measure and analyze medication-taking behavior. Automatic compilation of drug dosing history data facilitated by smart technology allows reliable and detailed assessment of adherence behavior over time. These products have been successfully validated to show that the clinical explanatory and predictive value of the resulting adherence data is significant. Accordingly, the US Food and Drug Administration recommended use of smart technology for drug development as a feedback mechanism to enhance patient adherence in clinical trials. Although these technologies provide richly sampled dosing history data that are critical for pharmacometric interpretation, technology-informed data alone are insufficient for patient care purposes.

Measures that use an identified proxy event remote from the actual medication-taking event produce less robust data. For example, calendared blister packaging has been proven to improve pharmacy claims-based adherence and persistence rates but these results tell little about individual pill-taking behavior. Unfortunately, convenience appears to be inversely correlated with insight into causes of nonadherence. In general, this further removed the proxy event from the ingestion or application of the medication, the less expensive and easier the method is to administer, yet the less valuable the data.

Simple indirect measurement techniques, such as self-reporting, structured interviews, and pill counts, are all subject to bias from a broad array of both provider and patient variables (e.g., recall, ineffective administration, and desirability bias). For example, the Patient Activation Measures and other self-report scales rely on direct assessment and results can be unpredictable due to human variability. As observed in their use with MTM, the quality of the data...
Table 1  Selected adherence measures according to study design

<table>
<thead>
<tr>
<th>Adherence metric</th>
<th>Description</th>
<th>Evaluation use, advantages, and disadvantages</th>
<th>Examples</th>
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<tbody>
<tr>
<td><strong>Direct</strong></td>
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<tr>
<td>Observational</td>
<td>• Direct face-to-face observation of patient medication-taking behavior</td>
<td>• Controlled settings that permit observation and where validation of adherence warrants expense: Oslo RDN Randomized Study (ClinTrialGov ID: NCT01673516) – candidates for renal denervation must first be verified as having true treatment-resistant hypertension through witnessed intake of the antihypertensive drugs as a means of reducing risk and cost.</td>
<td>• Face-to-face observation</td>
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<td></td>
<td>• Robust but subject to human circumvention</td>
<td>• When used in outpatient or uncontrolled clinical trial settings, may be subject to human circumvention or unwarranted cost</td>
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<td></td>
<td>• Expensive, burdensome to the health care provider</td>
<td>• Appropriate in controlled settings that permit physical measures and where validation of adherence warrants expense – such as in clinical settings where drug level or effect informs whether a patient is very likely nonadherence (i.e., INR of 1.0 on a previously therapeutic dose of warfarin or drug level of zero for phenytoin)</td>
<td>• Drug assays of blood or urine</td>
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<tr>
<td></td>
<td>• Not practical for routine clinical use (usually not feasible outside inpatient settings or clinical trials)</td>
<td>• Indirect assessment of the patient’s clinical response and/or physiological markers</td>
<td>• Use of drug markers with the target medication</td>
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<td></td>
<td></td>
<td>• Health outcomes</td>
<td>• Direct observation of patient use of medication</td>
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<tr>
<td>Blood measures</td>
<td>• Monitoring physical parameters provide indirect evidence of likelihood of adherence</td>
<td></td>
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<tr>
<td>of medication, metabolite, or biological marker</td>
<td>• Robust but subject to metabolic variation</td>
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<td></td>
<td>• “White coat syndrome” or “Hawthorne effect” may artificially inflate adherence measures</td>
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<td></td>
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<tr>
<td></td>
<td>• Not practical for routine clinical use (labor intensive and costly)</td>
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<td></td>
<td>• Point in time data that may be problematic for drugs with short half-lives</td>
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<tr>
<td><strong>Indirect</strong></td>
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<tr>
<td>Assessment of the patient’s clinical response and/or physiological markers</td>
<td>• Monitoring patient health outcomes/physiological status to determine adherence</td>
<td>• Controlled settings that permit physiological response/ outcome evaluation</td>
<td>• Health outcomes</td>
</tr>
<tr>
<td></td>
<td>• No “White coat syndrome” or “Hawthorne effect” to artificially inflate adherence measures</td>
<td></td>
<td>• Physiological status</td>
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<tr>
<td></td>
<td>• Subject to metabolic variation and concomitant disease factors</td>
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<tr>
<td></td>
<td>• When used as sole measure of adherence, results predictive but not likely to be conclusive</td>
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<tr>
<td>Self-reporting: patient questionnaires/diaries/structured interviews</td>
<td>• Inexpensive, relatively unobtrusive, provide patient perspectives and distinguish between intentional (process in which the patient actively decides not to use treatment or follow treatment recommendations) and unintentional (passively inconsistent medication-taking behavior such as forgetfulness or carelessness). Nonadherence has different underlying causes and therefore requires different interventions</td>
<td>• Appropriate in clinical practice applications to distinguish between intentional and unintentional nonadherence</td>
<td>• The PAM,37</td>
</tr>
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<td></td>
<td>• Useful in identifying patients who need assistance with their medications, assessing patient concerns, and evaluating new programs</td>
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<td>• SEAMS</td>
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<td></td>
<td>• Some are disease specific</td>
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<td>• 100-point VAS</td>
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<td></td>
<td>• For routine clinical practice, should be brief, acceptable to patients, valid, reliable, have the ability to distinguish between different types of nonadherence and be able to be completed by or in conjunction with caregivers where necessary</td>
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<td>• BMQ</td>
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<td>• MARS</td>
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The concordance of self-report and other measures of medication adherence varies widely based on the type of measures used. Measures asking respondents to report missed doses over-predict adherence subsequently monitored electronically, whereas global quantitative self-ratings were more concordant with adherence subsequently monitored electronically.

When used as sole measure of adherence results may be unreliable—potentially predictive but not likely to be conclusive.

“White coat syndrome” or “Hawthorne effect” and inaccurate patient recall may artificially inflate adherence measures.

<table>
<thead>
<tr>
<th>Medication event monitoring: electronic medication monitors/reminders</th>
<th>Medication monitoring: digital pill</th>
<th>Medication monitoring: pill counts (e.g., PT/PP)</th>
<th>PAMS (e.g., PDC, MPR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronics incorporated into packaging that records events that are proxy for medication taking (i.e., package opening)</td>
<td>Electronics incorporated into pill emits impulse to record pill-taking event</td>
<td>Counting missing pills as a proxy for medication taking</td>
<td>Objective estimates calculated from pharmacy data to assess the number of doses dispensed in relation to a dispensing period</td>
</tr>
<tr>
<td>Able to provide pharmacodynamic information through identification of variable exposure to drugs created by diversely erratic execution of dosing regimens</td>
<td>Provide insight into time of day and behavior patterns</td>
<td>Results may be predictive but not likely to be conclusive</td>
<td>Dispensing is a proxy for medication taking—built in upward bias that is especially pronounced when calculated over relatively short timeframes (&lt;9 months)</td>
</tr>
<tr>
<td>Some products scientifically validated</td>
<td>Provide information on adherence</td>
<td>Easy to perform</td>
<td>Accessible and relatively low cost</td>
</tr>
<tr>
<td>“White coat syndrome” or “Hawthorne effect” may artificially inflate adherence measures</td>
<td>“White coat syndrome” or “Hawthorne effect” may artificially inflate adherence measures</td>
<td>Subject to human circumvention</td>
<td>Appropriate only for chronic/long-term therapy</td>
</tr>
<tr>
<td>Costly</td>
<td>Patient acceptance issues</td>
<td>Does not accurately capture the timing of medication taking</td>
<td>To be accurate, requires that patients obtain their medications from one closed pharmacy system such that all pharmacy records are consolidated</td>
</tr>
</tbody>
</table>

Ideal in clinical trials

Potential for in-market use as part of clinician engagement strategy—lack of clarity regarding FDA regulatory status and enforcement discretion impacting market uptake

FDA regulated device—FDA 510 (k) premarket approval for ingestible sensors

“Hawthorne effect” may artificially inflate adherence measures

Commonly used in randomized, controlled clinical trials and when used as sole measure of adherence, results unreliable

Quality Measures and Reimbursement—pharmacy “quality” evaluation

Identify primary nonadherent patients failing to initiate therapy disadvantages such as “requires the patient obtain their meds within a closed pharmacy system”, “mail order/auto refills skew predictive values”, “misses hospital-supplied meds” not listed under group trajectory model measures?

| HAQ | BARS |
| MEMS | Helping Hand |
| GlowCaps | SIMpill |
| MERM | Digital Pill (Proteus, e-tech) |
| Pill count | |

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</table>
| Group trajectory model measures | • To gain a better perspective on PDC evaluation, add variables, such as income, education, and geography to evaluate a longer, more holistic perspective of adherence  
• Permits efficiency of pharmacy claims data use with a better understanding of adherence “patterns”  
• To be accurate, requires that patients obtain their medications from one closed pharmacy system such that all pharmacy records are consolidated  
• May facilitate targeting of interventions and may be useful to adjust for confounding by health-seeking behavior  
• Mail order/automatic refills skew predictive value  
• Misses hospital-supplied medication and cash paying patients  
• Limited to a snapshot of patient adherence at a point in time, for medications that treat chronic conditions  
• Current “therapeutic gap” between pharmacy and physician may make patient clinical management application ineffective  
• When used as sole measure of adherence, results predictive but not likely to be conclusive | • Ease of use of pharmacy data yielding more comprehensive evaluation of adherence patterns  
• Requires that patients obtain their medications within a closed pharmacy system to be accurate  
• Does not currently capture primary nonadherence without comprehensive EHR interoperability  
• Mail order/automatic refills skew predictive value  
• Misses hospital-supplied medication and cash paying patients | CVS/Brigham and Women’s Hospital recent research on a novel method, group-based trajectory models, for classifying patients by their long-term adherence.  
Will Shrank, Troy Brennan, Niteesh Choudry |

Abbreviations: BArS, Brief Adherence Rating Scale; BMQ, brief medication questionnaire; CVS, convenience value and service; EHR, electronic health record; FDA, Food and Drug Administration; HAQ, health assessment questionnaire; INR, international normalized ratio; MArS, medication adherence rating scale; MEMS, Medication Event Monitoring Systems; MErM, medication event reminder monitor; MPr, medication possession ratio; PAM, patient activation measure; PDC, proportion of days covered; PMN, primary medication nonadherence; PP, number of pills prescribed; PT, number of pills taken; SEAMS, self-efficacy for appropriate medication use scale; VAS, visual analogue scale.
obtained is highly dependent upon the practitioner–patient relationship.\textsuperscript{25} The concordance of these types of measures with actual adherence behavior varies widely based on the skill of the practitioner.\textsuperscript{26–28} Furthermore, data capture, collection, and use challenges exist, making these measures more complicated to effectively integrate into electronic health records, automated data capture systems, and clinical practice workflows.\textsuperscript{29}

Claims data derived from pharmaceutical distribution represent another example of indirect data capture. The Pharmacy Quality Alliance developed, tested, and endorsed the most widely and currently referenced set of adherence metrics, the Pharmacy Adherence Measures, which include Proportion of Days Covered and MPR.\textsuperscript{30} Focused on prescription filling dates and days of therapy supplied for each fill of a prescription, these adherence measures use the event of “a filled prescription leaves the pharmacy” as a proxy for medication taking. The measures are used predominantly as performance measures for health plans, pharmacy benefit managers and managed care organizations for which claims data are relatively accessible and inexpensive. In addition, because of their ease of use and scalability, these measures have become a mainstay in both the evaluation of personalized adherence interventions and the design of adherence programs in various settings. Although studies confirm that these type of data reliably indicate drug exposure and associated clinical effect, they can be used primarily to study chronic, not acute, treatments\textsuperscript{31} and do not provide the type of granularity necessary to understand causal factors once a nonadherent population is identified. Furthermore, adherence calculated through claims data is less reliable for nonoral medication types including injectable, transdermal, and inhaler dosage forms where the amount of medication associated with a single dose is less easy to quantify and for medications that require frequent titration and dose adjustment such as oral anticoagulants.\textsuperscript{19}

The Pharmacy Quality Alliance’s most popular claims-based measure, the Primary Medication Non-Adherence measure, recently endorsed by the Centers for Medicare and Medicaid Services, attempts to refine the purpose for which claims analysis is undertaken.\textsuperscript{31} By refocusing from general nonadherence to noninitiation, this metric permits greater insight into patient medication-taking behavior and theoretically narrows the scope of choice of intervention to those geared toward addressing noninitiation. However, the measure alone renders insufficient data upon which to base comprehensive intervention design decisions. Other promising new methods of adherence measurement attempt to serve the same end by subjecting pharmacy claims data to group-based trajectory modeling.\textsuperscript{32} These measures show potential to help health care professionals appropriately target interventions and evaluate associated clinical outcomes. They allow researchers to move beyond over-simplified classification of patients as “adherent or not” and more accurately capture and describe adherence.\textsuperscript{32}

For medication adherence measures to effectively inform decision making about supportive interventions at the individual patient level, the intervention selection, delivery and intensity must be matched with each patient’s needs.\textsuperscript{33} Without insight into those needs, decisions will necessarily be uninformed. Using well-selected, robust measures will yield comprehensive insight into behavior patterns, allowing pharmacists and providers to elicit patient feedback and address the root cause of individual nonadherence.\textsuperscript{14,35}

**Implications**

The need to understand patient medication nonadherence at the individual level becomes more critical as the cost and complexity of available interventions increases. As stakeholders in the health care market contemplate solutions for nonadherence, success at both the patient and population level will depend upon an educated understanding of adherence measures and interventions. Counting “possession” devoid of an exponent for rationale will cause enough error in the equation as to render it useless for driving change in the real world. Indeed, the era of big data offers much to measure. We have come full circle to recognize that metrics for measurement’s sake, without a conversation to interpret, integrate, and accommodate the importance of the constraints of everyday life on the individual, yield numbers of little value for prospective treatment choices. As patient-reported outcome measures gain momentum on the national stage, opportunities to use these measures more effectively may help close the gap on the social costs of our current inaccuracy.

**Disclosure**

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