



Improving the Appropriate Use of Transthoracic Echocardiography

The Echo WISELY Trial

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ABSTRACT

BACKGROUND Appropriate use criteria (AUC) have defined transthoracic echocardiogram (TTE) indications for which there is a clear lack of benefit as rarely appropriate (rA).

OBJECTIVES This study sought to investigate the impact of an AUC-based educational intervention on outpatient TTE ordering by cardiologists and primary care providers.

METHODS The authors conducted a prospective, investigator-blinded, multicenter, randomized controlled trial of an AUC-based educational intervention aimed at reducing rA outpatient TTEs. The study was conducted at 8 hospitals across 2 countries. The authors randomized cardiologists and primary care providers to receive either intervention or control (no intervention). The primary outcome measure was the proportion of rA TTEs.

RESULTS One hundred and ninety-six physicians were randomized, and 179 were included in the analysis. From December 2014 to April 2016, the authors assessed 14,697 TTEs for appropriateness, of which 99% were classifiable using the 2011 AUC. The mean proportion of rA TTEs was significantly lower in the intervention versus the control group (8.8% vs. 10.1%; odds ratio [OR]: 0.75; 95% confidence interval [CI]: 0.57 to 0.99; $p = 0.039$). In physicians who ordered, on average, at least 1 TTE per month, there was a significantly lower proportion of rA TTEs in the intervention versus the control group (8.6% vs. 11.1%; OR: 0.76; 95% CI: 0.57 to 0.99; $p = 0.047$). There was no difference in the TTE ordering volume between the intervention and control groups (mean 77.7 ± 89.3 vs. 85.4 ± 111.4 ; $p = 0.83$).

CONCLUSIONS An educational intervention reduced the number of rA TTEs ordered by attending physicians in a variety of ambulatory care environments. This may prove to be an effective strategy to improve the use of imaging. (A Multi-Centered Feedback and Education Intervention Designed to Reduce Inappropriate Transthoracic Echocardiograms [Echo WISELY]; [NCT02038101](https://clinicaltrials.gov/ct2/show/study/NCT02038101)) (J Am Coll Cardiol 2017;70:1135-44) © 2017 by the American College of Cardiology Foundation.



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ABBREVIATIONS AND ACRONYMS

- A** = appropriate
- AHRC** = Applied Health Research Centre
- ASE** = American Society of Echocardiography
- AUC** = appropriate use criteria
- CI** = confidence interval
- mA** = may be appropriate
- OR** = odds ratio
- rA** = rarely appropriate
- TTE** = transthoracic echocardiogram

Overuse of low-value clinical services has received greater attention in recent years in response to an Institute of Medicine report that estimated 30% of health care dollars are spent on services that do not improve patient care (1). The Choosing Wisely campaigns have sought to raise awareness of low-value tests, treatments, and procedures that are potentially unnecessary and may cause harm (2). In response to concerns regarding significant increases in the use of cardiac testing (3), some of which may be of low value, the American College of Cardiology published its first Appropriate Use Criteria (AUC) document in 2005 (4), and then subsequently published multiple documents covering the majority of cardiovascular imaging and procedures (5-8).

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Clinical application of the AUC has been considered as a mechanism to curb the rising use of cardiac testing that may be low value. A small number of prior studies have assessed the ability to change physician behavior with AUC-based interventions. Studies have evaluated the impact on ordering of echocardiography, single-photon emission computed tomography, and coronary computed tomography angiography (9-14) and achieved various levels of success. The previously published studies have been predominantly single-center, nonrandomized studies with a limited sample size and duration of intervention (15).

Recently, our group published the results of a single-center, randomized controlled trial of an educational intervention designed to reduce the frequency of rarely appropriate (rA) transthoracic echocardiograms (TTE) ordered by attending cardiologists (16). The findings demonstrated a significantly lower proportion of rA TTEs ordered by the intervention group (16). It remains unknown whether this type of intervention can be generalized across multiple practice environments, particularly across countries where payment systems differ. To investigate this question, we conducted the first multicenter, investigator-blinded, randomized controlled trial of

an educational intervention designed to reduce the proportion of rA TTEs ordered in ambulatory care.

METHODS

STUDY DESIGN. The design of the Echo WISELY (Will Inappropriate Scenarios for Echocardiography Lessen Significantly) study was previously published (17). The Echo WISELY study is an international, multi-center, investigator-blinded, randomized controlled trial to evaluate the effects of an AUC-based education and feedback intervention versus usual care on the proportion of rA TTEs ordered by clinicians in ambulatory care. The study is registered at ClinicalTrials.gov (NCT02038101), reported in accordance with Consolidated Standards of Reporting Trials (CONSORT) guidance, and approved by the research ethics board of each participating hospital. Funding was provided by the Peter Munk Cardiac Centre (Toronto, Ontario, Canada), the Ontario Ministry of Health and Long-Term Care, and the Cardiac Care Network of Ontario. The authors are solely responsible for the design, conduct, and analysis of this study, as well as the drafting and editing of the paper, and its final contents.

PARTICIPANTS, HOSPITALS, AND RECRUITMENT. Attending cardiologists and primary care physicians who practice ambulatory care were recruited at 8 hospitals (7 in Ontario, Canada, and 1 in Massachusetts). The hospitals represented a broad mix of large academic medical centers (University Health Network, Mount Sinai Hospital, Sunnybrook Health Sciences Centre, Brigham and Women's Hospital, St. Michael's Hospital), smaller ambulatory centers (Women's College Hospital), and rural hospitals (Kingston General Hospital).

Only physicians who saw patients in an ambulatory care setting were eligible to participate. Pediatric cardiologists and physicians who specialize primarily in adult congenital heart disease were excluded. Eligible physician practices were screened for pre-existing decision support processes for outpatient TTE ordering, and if such a system was in existence, those physicians were excluded from participation.

STUDY PROCEDURE. Following informed consent, study participants were assigned a unique study ID

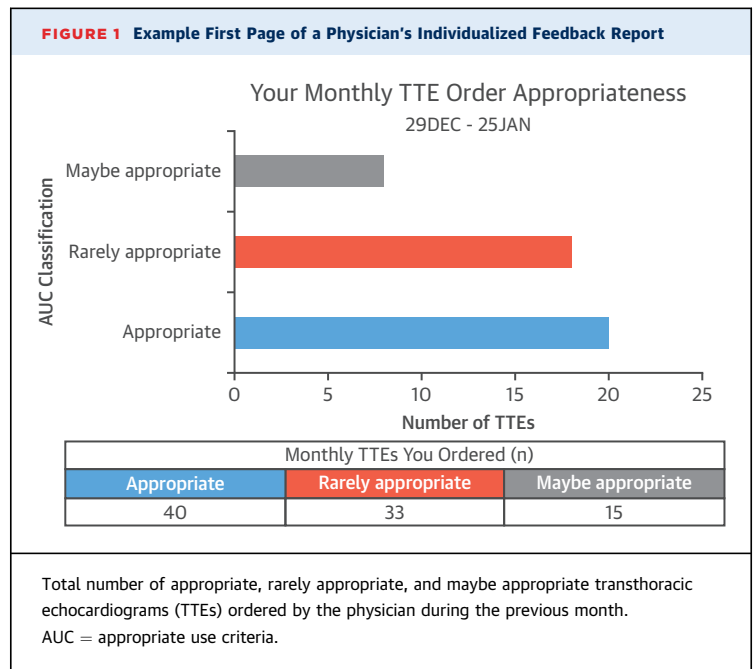
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and were randomized 1:1 to either usual care (control group) or an AUC-based education and feedback intervention (intervention group). Randomization was stratified by hospital site and by physician specialty (cardiologists or general practitioners, which included internal medicine physicians and family physicians) to generate equal numbers of participants in each study arm and minimize potential confounding variables.

AUC-BASED EDUCATION AND FEEDBACK INTERVENTION. Physicians in the intervention arm received a multifaceted educational intervention on appropriate use of TTE ordering via e-mail that included: 1) a 20-min video lecture at the beginning of the study period that described the AUC for echocardiography and highlighted common clinical scenarios for which outpatient TTEs are ordered; 2) instructions on how to download the American Society of Echocardiography (ASE) decision support mobile application for Google Android or Apple products, as well as a PDF of the AUC for those who did not have access to a mobile device; and 3) monthly feedback reports summarizing their individual TTE ordering behavior. The feedback reports included total number of rA, may be appropriate (mA), and appropriate (A) TTEs ordered by the physician the previous month and cumulatively over the length of study participation, the top 5 AUC indications for rA TTEs ordered by the physician, and a comparison of cumulative rA TTEs ordered by themselves compared with the other participants at their site. Feedback reports were e-mailed to the physician approximately every 4 weeks for the duration of the study; the total number of rA, mA, and A TTEs ordered by the physician the previous month were provided in a PDF attachment, and a URL link was provided to allow physicians access to their complete individualized reports, which were made available via an education tracking tool, Articulate Online (Articulate Global, New York, New York). This service allowed tracking of the intervention use by monitoring the activity of each of the physicians in the intervention group when accessing the training materials and reviewing their feedback reports. **Figure 1** shows an example of the first page of the feedback report.

CLASSIFICATION OF TTE APPROPRIATENESS. Site research coordinators received standardized training on the study protocol and were instructed by a study investigator on proper use of the 2011 AUC for echocardiography to classify the appropriateness of TTEs ordered (8). Each site research coordinator was blind to the physicians' group allocations and abstracted the clinical reasons for each TTE ordered by



independently reviewing the TTE order and the patient's medical record, including patient history, assessment, and plan, and any prior medical imaging orders. The clinical information associated with each TTE was used to classify the TTE as A, mA, or rA based on the 2011 AUC for echocardiography (8), and reflecting the new appropriateness nomenclature. If the clinical reason for ordering the TTE lacked a corresponding indication in the 2011 AUC, it was recorded as unclassifiable. TTEs with insufficient clinical data to make an appropriate use designation were deemed unclassifiable and were not included in the study.

An escalating 2-tiered clarification process was used if the site research coordinator was unable to classify a TTE. First, the research coordinator completed a clarification request form with deidentified information to request the site principal investigator to classify the TTE. All site principal investigators were echocardiographers with Level III training. If the site principal investigator was unable to classify the TTE, then the deidentified clarification request form was forwarded to a clarification committee consisting of 3 senior study investigators, each from a different institution (R.S.B., R.B.W., J.E.).

DATA COLLECTION AND MANAGEMENT. Data management was centrally coordinated by the Applied Health Research Centre (AHRC), an academic research organization at St. Michael's Hospital in Toronto, Canada. The AHRC created and hosted a secure, web-based database using Research Electronic Data

Capture (REDCap) software (REDCap Consortium, The Vanderbilt University, Nashville, Tennessee) (18). Data was collected by each site research coordinator on an ongoing basis. For each TTE ordered by a participating site physician, the research coordinator entered the deidentified physician study identification, date of TTE, and AUC data (if the TTE was classifiable, the appropriateness and indication number, and details of any assistance required for clarification). Data management on completeness, and preparation and distribution of the intervention and monthly feedback reports to physicians in the intervention group was performed at the AHRC.

STUDY OUTCOMES. The primary outcome was comparing the proportion of rA TTEs ordered between the 2 treatment groups. Secondary outcomes included: 1) the overall TTE ordering volume per group; 2) the proportion of rA-ordered TTEs over time; and 3) the most common indications for TTEs based on appropriateness category.

STATISTICAL ANALYSIS. An intention-to-treat approach was taken throughout analysis of the outcomes. All of the analyses were planned a priori. The physicians were the unit of randomization and measurement in this analysis. The primary outcome, the proportion of rA TTEs ordered, was analyzed using a beta-binomial regression model. The treatment effect was expressed as an odds ratio (OR) with a 95% confidence interval (CI). This outcome was first analyzed for all physicians and then, as a planned secondary analysis, for only those physicians who ordered at least 1 TTE per month while they were in the study. The secondary outcome, total number of TTEs ordered, was analyzed with a Poisson regression model including the logarithm of length of observation time as an offset term. The treatment effect was expressed as a rate ratio with 95% CIs. Unlike the other analyses, investigation of TTE ordering over time treated individual TTEs as the unit of analysis and inference. A logistic generalized estimating equation was constructed to estimate the proportion of rA TTEs between treatment groups across study time. All of the models described in the preceding text investigated the impact of treatment on outcomes while adjusting for physician specialty (cardiology or general practitioner). We also planned an exploratory analysis estimating the proportion of rA-ordered TTEs with only the cardiologist subjects. Subgroup analyses were performed for physician location (American vs. Canadian), type of physician, and hospital using an interaction between the treatment group and the subgroup variable with the proportion of rA TTEs as outcome. In addition to regression, the most common

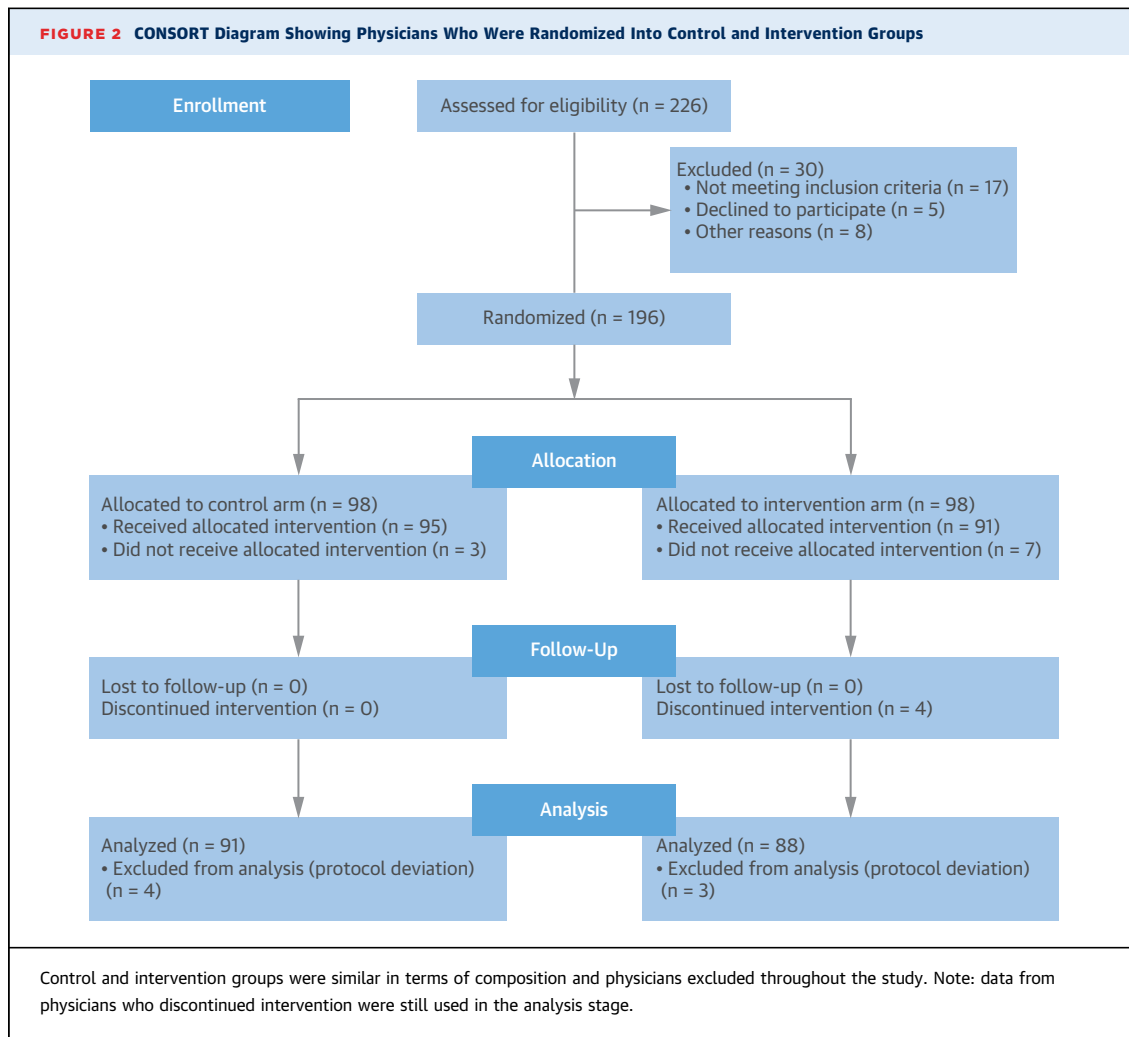
indications for rA, A, and mA TTEs were summarized descriptively.

In order to test the primary hypothesis with 80% power at a 5% level of significance and assuming a control rA rate of 25%, we estimated a necessary sample size of 180 physicians ($n = 90$ in each treatment group) with each physician ordering 30 TTEs per year to detect an absolute reduction of 5%. Because randomization was at the physician level, but the outcome data was measured within each cluster (physician), a modest intraclass correlation of 0.05 was assumed.

RESULTS

STUDY PARTICIPANTS. As shown in the CONSORT diagram (Figure 2), a total of 226 physicians were assessed for eligibility. Of those screened, 30 physicians were excluded from randomization: 17 did not meet eligibility criteria (9 practiced primarily adult congenital cardiology and 8 practiced exclusively in the inpatient setting); 8 were excluded for other reasons (e.g., involvement in the creation of the AUC or the ASE's decision-support mobile AUC application); and 5 declined to participate. A total of 196 physicians were randomized (98 allocated to the control group and 98 allocated to the intervention group). Of those who were randomized, 10 withdrew their consent before study initiation (3 in the control group and 7 in the intervention group). Data entry errors at 1 site (Scarborough General Hospital) excluded an additional 7 physicians (4 in the control group and 3 in the intervention group) from the analysis. A total of 179 physicians were included in the analysis (91 physicians in the control group and 88 physicians in the intervention group), which included 4 physicians in the intervention group who were withdrawn from the study before completion (3 left their institution and 1 withdrew consent).

TTEs ORDERED. From December 1, 2014, to April 17, 2016, a total of 14,697 TTEs were assessed for appropriate use classification using the 2011 AUC for echocardiography. Overall, 14,608 (99.4%) of TTEs assessed were classifiable. The site research coordinator required assistance in classifying 135 of the TTEs, 134 were resolved by site-level clarification from the site principal investigator, and 1 required adjudication by the central committee. Among the classifiable TTEs, 1 echocardiogram was excluded from analysis due to issues of data quality, resulting in 14,607 TTEs eligible for analysis. Table 1 summarizes the frequency of TTEs by classification category and treatment group.



RATE OF TTE ORDERING. After adjusting for length of time observed and physician specialty, there was no statistically significant difference in the total number of TTEs ordered between the intervention (mean 77 ± 89 TTEs/physician) and control groups (mean 85 ± 111 TTEs/physician; rate ratio 2.62; 95% CI: 0.80 to 8.62; $p = 0.83$). The study was not powered, however, to assess differences in ordering volume, because we did not have the patient volumes per physician in each of the groups. As a consequence of the differences in ordering practices among physicians, the variance in ordering volumes are large.

TTE APPROPRIATE USE CLASSIFICATION. Of the 179 participants considered, 26 physicians did not order a single TTE during the study period and were thus excluded from the primary analysis. **Table 1** shows the proportion of rA, A, and mA TTEs among physicians who ordered at least 1 TTE ($n = 153$) by treatment group. Adjusting for physician specialty (cardiologist

TABLE 1 Appropriateness of TTEs Ordered by Intervention and Control Group

	Intervention	Control	OR* (95% CI)	p Value
Proportion of TTEs ordered by appropriateness category and treatment group				
Total TTEs	6,899	7,798	—	—
Classifiable	6,835 (99.1)	7,772 (99.7)	—	—
A	5,746 (84.0)	6,307 (81.2)	—	—
mA	443 (6.5)	499 (6.4)	—	—
rA	646 (9.5)	966 (12.4)	—	—
Proportion of TTEs ordered by appropriateness category and treatment group for physicians with ≥ 1 TTE				
Total no. of physicians	74	79	—	—
rA	8.8 ± 9.5	10.1 ± 8.1	0.75 (0.57-0.99)	0.039
mA	5.7 ± 6.6	5.0 ± 5.3	—	—
A	85.5 ± 12.5	84.9 ± 9.8	—	—

Values are n, n (%), or mean \pm SD, unless otherwise indicated. Among the classifiable TTEs ($n = 14,607$ total), the number of TTEs in each appropriateness category (along with the column %) is shown. With results from beta-binomial regression (primary analysis) assessing the association between treatment and proportion of rA TTEs among physicians with at least 1 TTE ordered (n physicians = 153; n TTEs = 14,907). *OR adjusted for physician specialty (cardiologist or general practitioner).
 A = appropriate; CI = confidence interval; mA = maybe appropriate; OR = odds ratio; rA = rarely appropriate; TTE = transthoracic echocardiogram.

TABLE 2 Proportion of TTEs Ordered by Appropriateness Category and Treatment Group for Physicians With ≥ 1 TTE/Month

	Intervention (n = 66)	Control (n = 66)	OR* (95% CI)	p Value
rA	8.6 \pm 7.7	11.1 \pm 7.4	0.76 (0.57-0.99)	0.047
mA	5.8 \pm 5.8	5.6 \pm 5.1	—	—
A	85.6 \pm 9.9	83.3 \pm 8.6	—	—

Values are mean % \pm SD unless otherwise indicated. With results from beta-binomial regression (primary analysis) assessing the association between treatment and proportion of rA TTEs among physicians with at least 1 TTE ordered per month followed (n physicians = 132; n TTEs = 14,451). *OR adjusted for physician specialty (cardiologist or general practitioner). Abbreviations as in [Table 1](#).

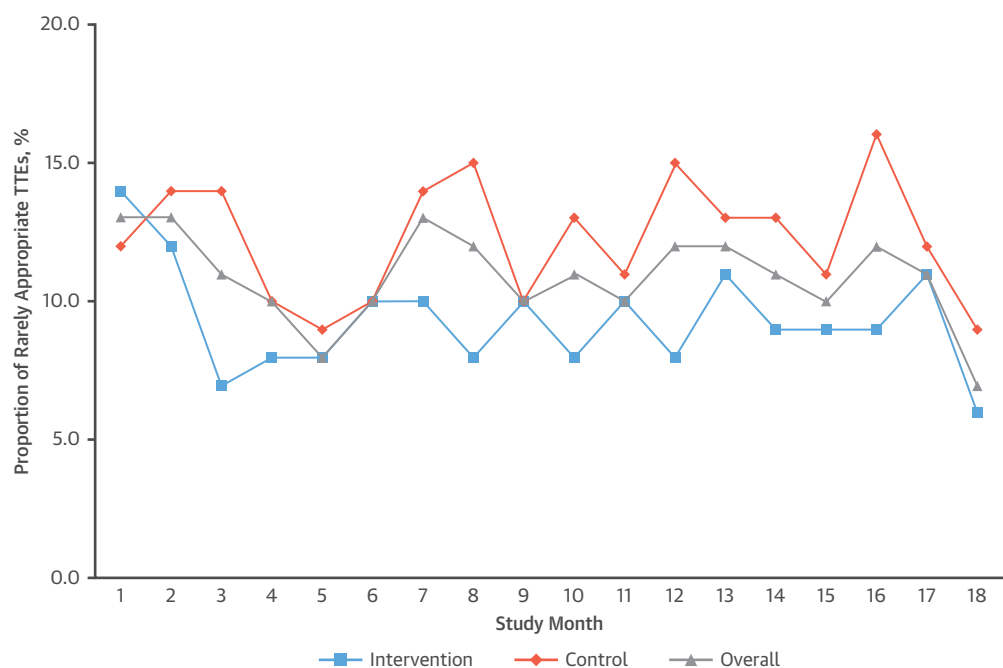
or general practitioner), the proportion of rA TTEs was significantly lower in the intervention group (8.8%) than in the control group (10.1%; OR: 0.75; 95% CI: 0.57 to 0.99; $p = 0.039$).

Among physicians who ordered at least 1 TTE per month (n = 132), an equal number belonged to each treatment group. [Table 2](#) shows that the proportion of rA TTEs ordered was significantly lower among those in the intervention group versus the control group (8.6% vs. 11.1%; OR: 0.76; 95% CI: 0.57 to 0.99; $p = 0.047$) after adjusting for physician specialty.

IMPACT OF THE INTERVENTION OVER TIME. [Figure 3](#) shows the proportion of rA TTEs ordered for each month of the study period. After adjusting for the month in which the TTE was ordered and physician specialty, the impact of the intervention did not wane over time (OR: 0.98; 95% CI: 0.94 to 1.00; $p = 0.17$).

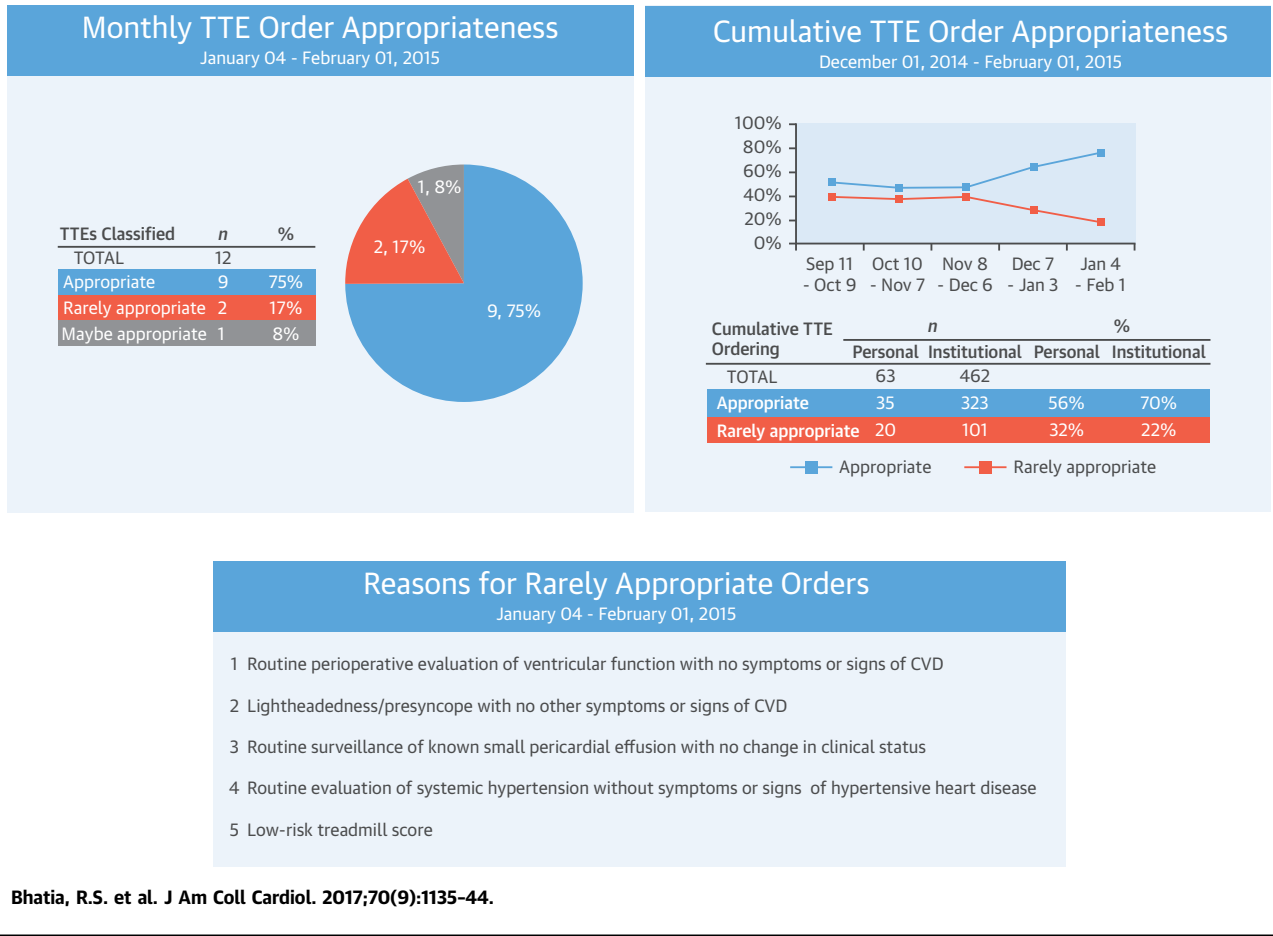
PHYSICIAN SPECIALTY. Among those physicians with at least 1 TTE ordered, 134 were cardiologists and 19 were primary care physicians. As stated, primary analysis indicated a significant treatment effect after adjusting for physician specialty. Compared with cardiologists, primary care physicians ordered a lower proportion of rA TTEs (10.6% vs. 1.1%; OR: 0.14; 95% CI: 0.04 to 0.44; $p < 0.001$). When we analyzed only the cardiologists, there is a similar difference in the proportion of rA TTEs ordered between intervention and control groups (10.0% vs. 11.3%; OR: 0.76; 95% CI: 0.58 to 1.00; $p = 0.0502$).

PRACTICE LOCATION. Two subgroup analyses, classified separately by country and by hospital, were performed to investigate the impact of physician location on treatment effect. Of the physicians analyzed in the primary analysis, 58 (38%) were from the United States and 95 (62%) were from Canada.

FIGURE 3 Proportion of Rarely Appropriate TTEs Over Time Ordered by Treatment Group Throughout the 18 Months of the Trial

The monthly proportion of the rarely appropriate transthoracic echocardiograms (TTEs) ordered in the overall group (triangles), the control group (diamonds), and the intervention group (squares). Abbreviations as in [Figure 1](#).

CENTRAL ILLUSTRATION An Example of a Monthly Feedback Report Provided to Physicians in the Intervention Arm of the Study



Top left: The proportion of monthly transthoracic echocardiograms (TTEs) ordered that are appropriate, rarely appropriate, and maybe appropriate. **Top right:** The cumulative proportion of appropriate TTEs. **Bottom:** The top 5 reasons for ordering rA TTEs within the month. CVD = cardiovascular disease.

The effect of treatment group on the proportion of rA TTEs ordered did not differ significantly between U.S. and Canadian physicians (OR: 0.78; 95% CI: 0.44 to 1.38; p = 0.40).

MOST COMMON INDICATIONS FOR TTE BY APPROPRIATE USE CLASSIFICATION. Online Table 1 shows the most common indications for rA TTEs among both the intervention and control groups. Irrespective of study group, the top 3 indications for an rA TTE were: routine surveillance of a prosthetic valve (<3 years) if no known or suspected dysfunction (AUC indication #48); routine surveillance of ventricular function in patients with known coronary artery disease and no change in clinical status or cardiac exam (AUC indication #11); and routine surveillance (<1 year) of moderate or severe valvular

stenosis without a change in clinical status or cardiac exam (AUC indication #40).

USE OF THE INTERVENTION. We tracked the number of times that study participants in the intervention group logged in to view either the educational material or the feedback reports. In total, 54 physicians in the study group (61% of the intervention group) logged into the system at least 1 time. Physicians mainly logged on to view feedback reports (70% of the time).

DISCUSSION

This study, to our knowledge, is the first prospective, multicenter, investigator-blinded, randomized controlled trial of an AUC-based intervention aimed at outpatient TTE ordering by attending physicians. This

intervention, comprising an educational session and recurrent feedback reports, an example of which is shown in the **Central Illustration**, significantly reduced rA TTE ordering, and the effect was similar between physician groups and across countries. Moreover, the effect on TTE ordering behavior did not significantly dissipate over the course of the intervention. Therefore, this intervention may represent a viable strategy to reduce potential low-value TTE use and increase adherence to best-practice guidelines.

The results of the Echo WISELY study add significantly to existing published reports on interventions designed to reduce low-value care. The majority of the existing studies on this subject are nonrandomized and single center. For example, our group showed that this type of intervention can significantly improve the appropriateness of TTE ordering in medical and cardiology trainees, as well as in attending staff in single-center studies (10,11,16). A recent meta-analysis of interventions designed to improve appropriate ordering found that audit- and feedback-based interventions can lower rates of rA cardiac testing, although the studies were small, single center, and predominantly observational (19). The results of the current study parallel those of a more general Cochrane review, which found that audit and feedback can lead to important improvements in professional practice, and cited key success factors, including providing written feedback multiple times with a clear action plan (20). The Echo WISELY intervention followed many of the key elements from the prior single-center studies and the Cochrane review, including monthly feedback reports, provided by e-mail, that included areas of ordering improvement for each physician. We noted that the majority of physicians, despite the many demands on their time, did not simply view the e-mail feedback, but accessed Articulate Online to view the educational material and their detailed feedback reports, suggesting significant interest by physicians in receiving the intervention.

It is noteworthy that the intervention group did have significantly reduced rA ordering compared with the control group, even after adjusting for physician specialty, and that the observed proportion of rA TTEs was lower than anticipated among controls. In the study design, we anticipated the proportion of rA TTEs ordered in the control group to be 25%, based on prior retrospective studies of TTE ordering appropriateness (21,22), whereas the actual proportion of rA TTE was less than one-half of the estimate. There may be valid reasons for this lower rA proportion in the control group. First, there has been general improvement in appropriate TTE ordering since the launch of AUC and, perhaps, influence by campaigns

that focus on resource stewardship, such as the Choosing Wisely campaign (2,21). Second, it is certainly possible that study participants in the control group experienced a “Hawthorne” effect, where participants modify their behavior in response to their awareness of being observed (23). Despite the lower rate of rA TTEs in the control group, the intervention group still demonstrated a significantly lower proportion of rA TTEs.

The results of this study have significant public policy implications that may extend beyond echocardiography to other cardiac testing and medical imaging modalities. Previous attempts to curb the use of medical imaging have focused on point-of-care decision support tools and prior authorization programs. However, prior authorization programs often increase physician administrative burden and may deny up to 15% to 20% of individual medical imaging tests, but their efficacy has not been studied in a systematic way (24). The use of educational interventions along with audit and feedback may provide an important physician-driven alternative to the more “top-down” approaches (25), which also appear to transcend the payment environment. This approach is also advantageous because it focuses on overall trends in appropriateness, which allows physicians to maintain ordering autonomy as it pertains to individual tests. Although the overall impact of the intervention appeared modest, the potential for significant reductions in low-value cardiac testing, when applied across a large population, is substantial. Future research efforts should be directed to large, community-based practices to assess the broad impact and sustainability of the intervention.

STUDY LIMITATIONS. This study has several important limitations that should be noted. The first is that the sites were predominantly academic medical centers, and therefore the generalizability of the results to the community environment is unknown. Second, the sustainability of the impact of this type of intervention needs further study, as prior studies have shown conflicting data on the effectiveness of such interventions over time. Finally, the impact of adherence to AUC on patient outcomes and cost-effectiveness requires future study. Despite these limitations, the Echo WISELY study has shown that a straightforward intervention can significantly reduce potentially unnecessary medical testing across numerous practice environments and health care systems.

CONCLUSIONS

Physicians who received an AUC-based intervention, featuring education along with audit and feedback,

ordered a lower proportion of rA TTEs than controls. This intervention appeared to be equally effective in different physician types and payment environments, and the effect seemed to be maintained over time. This type of intervention could be considered as a strategy to curb the use of low-value imaging services.

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PERSPECTIVES

COMPETENCY IN PROFESSIONALISM: Education of physicians about the appropriate use of echocardiography can improve resource utilization in ambulatory care settings.

TRANSLATIONAL OUTLOOK: Although the educational intervention reduced ordering echocardiography for rarely appropriate indications during the study period, further investigation is required to assess the feasibility and long-term durability of this approach.

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APPENDIX For a supplemental table, please see the online version of this article.