Transparent Reporting of Multivariable Prediction Models in Journal and Conference Abstracts: TRIPOD for Abstracts

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Clear and informative reporting in titles and abstracts is essential to help readers and reviewers identify potentially relevant studies and decide whether to read the full text. Although the TRIPOD (Transparent Reporting of a multivariable prediction model for Individual Prognosis Or Diagnosis) statement provides general recommendations for reporting titles and abstracts, more detailed guidance seems to be desirable. The authors present TRIPOD for Abstracts, a checklist and corresponding guidance for reporting prediction model studies in abstracts.

A list of 32 potentially relevant items was the starting point for a modified Delphi procedure involving 110 experts, of whom 71 (65%) participated in the web-based survey. After 2 Delphi rounds, the experts agreed on 21 items as being essential to report in abstracts of prediction model studies. This number was reduced by merging some of the items. In a third round, participants provided feedback on a draft version of TRIPOD for Abstracts.

The final checklist contains 12 items and applies to journal and conference abstracts that describe the development or external validation of a diagnostic or prognostic prediction model, or the added value of predictors to an existing model, regardless of the clinical domain or statistical approach used.

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The TRIPOD (Transparent Reporting of a multivariable prediction model for Individual Prognosis Or Diagnosis) statement was published in 2015 to improve the reporting of multivariable prediction models (1, 2). It lists 22 items that are considered essential for informative reporting of prediction model studies. The statement covers diagnostic and prognostic studies and applies to all types of prediction model studies (development, external validation, and added value of predictors to existing prediction models) across all clinical domains.

In a recent study, we assessed the completeness of reporting of 170 prediction model studies that were published before the TRIPOD statement in 146 clinically diverse publications (3). We found that prediction model studies were generally poorly reported. Items on the title and abstract were the worst affected: Fewer than 10% of assessed models were completely reported according to TRIPOD. Part 1 of the **Supplement** (available at Annals.org) provides more details on reporting in titles and abstracts of prediction model studies.

Titles and abstracts are, however, essential elements of a study report that facilitate the identification of potentially relevant studies by automated searches and provide the information readers need to decide whether to read the full text. Because the TRIPOD statement provides only brief guidance on titles and abstracts, we aimed to develop a list of essential items for reporting studies about diagnostic or prognostic multivariable prediction models in journal and conference abstracts (TRIPOD for Abstracts), accompanied by further explanation and elaboration.

See also:

Web-Only
Supplement

Development of TRIPOD for Abstracts

Part 2 of the **Supplement** (available at Annals.org) describes the survey methods and results in detail.

First, an executive committee was formed (D.G.A., G.S.C., J.B.R., K.G.M.M., L.H., and P.H.) and established an initial list of 32 potentially relevant items for inclusion in abstracts of multivariable prediction model studies, based on items of the TRIPOD statement (1, 2) and existing reporting guidelines for abstracts (CONSORT [Consolidated Standards of Reporting Trials] for Abstracts, PRISMA [Preferred Reporting Items for Systematic reviews and Meta-Analyses] for Abstracts, and STARD [Standards for the Reporting of Diagnostic Accuracy Studies] for Abstracts) (4–7) (**Supplement Table 2**, available at Annals.org).

This initial list was the starting point for a modified Delphi procedure among the members of the original TRIPOD Group and other clinical epidemiologists, statisticians, clinicians, and journal editors with an interest in prediction model research. Potential panel members were invited by e-mail to participate in a web-based survey of 3 rounds with the aim of reaching consensus on items essential to report in abstracts of prediction model studies. Of 110 invitees, 71 (65%) responded, of whom 69 completed the first round. Among the respondents were 65 clinical epidemiologists, methodologists, or statisticians (92%); 10 clinicians (14%); and 6 journal editors (8%) (participants could be classified in >1 of these categories).

After 2 rounds, the Delphi panel had agreed on 18 items as being essential to report in abstracts of prediction model studies. On the basis of high agreement scores in the first 2 rounds, the executive committee considered another 3 items to be eligible. Following respondents' suggestions to merge some of the resulting 21 items, the draft version of TRIPOD for Abstracts

consisted of 11 items (**Supplement Table 5**, available at Annals.org).

The panel was asked to comment on this draft version in a third survey round. Of 52 respondents (73%), 19 (37%) agreed with the draft version without making any comments or suggestions. Thirty-three respondents (63%) provided feedback on 1 or more items. This feedback was discussed during a consensus meeting with all authors. The wording of items was refined, and 1 item on protocol availability was added to conform with other reporting guidelines for abstracts. After the consensus meeting, the final version of TRIPOD for Abstracts was prepared for publication.

TRIPOD FOR ABSTRACTS

TRIPOD for Abstracts is a checklist of 12 items that are considered essential for inclusion in all abstracts of prediction model studies (**Table**). We developed a single checklist that can be used for all types of prediction model studies (including those of development, external validation, added value, and model updating), all types of clinical domains, and all types of predictors and outcomes regardless of the statistical approaches used (including artifical intelligence and machine-learning approaches). The checklist items follow the usual structure of an abstract and are grouped under the headings Title, Background, Objectives, Methods, Results, and Discussion, with an additional item on Registration. All but 1 of the items overlap with items from the original TRIPOD statement (**Supplement Table 7**, available at Annals.org). We suggest that readers consult the explanation and elaboration document that was published alongside the TRIPOD statement for detailed clarification of concepts, if needed (2). TRIPOD for Abstracts more explicitly addresses updating of prediction models and prediction model studies using artificial intelligence or machine-learning techniques than did the original TRIPOD statement.

We now address the 12 items in TRIPOD for Abstracts, each accompanied by an empirical example and, if needed, explanation. Part 3 of the **Supplement** (available at Annals.org) provides examples of adequate reporting in abstracts of prediction model studies that came from varying medical disciplines and used varying statistical approaches.

Title

Item 1: Identification of the study as developing, validating, or updating a prediction model; the target population; and the outcome to be predicted.

Example

Development and validation of a model to predict the risk of exacerbations in chronic obstructive pulmonary disease (8).

Explanation

An informative title requires the following 4 aspects: the term "prediction model" or a synonym, the type of prediction model study (that is, development, external validation, added value, model updating, or a

Table. Essential Items to Include When Reporting Multivariable Prediction Model Studies in Journal or Conference Abstracts

Item	Description
Title	
1	Identification of the study as developing, validating, or updating a prediction model; the target population; and the outcome to be predicted.
Background	
2	A brief explanation of the health care context (including whether diagnostic or prognostic) and rationale for developing, validating, or updating the model.
Objectives	
3	Study objectives, including whether the study describes the development, validation, or updating of a model. For validation of an existing model, give the name or describe the model being validated.
Methods	
4	Study design or source of data (e.g., cohort, registry, routine care data, or randomized trial), separately for the development and validation data sets, if applicable.
5	Participant eligibility criteria and setting where the data were collected.
6	Outcome to be predicted by the model, including time horizon of predictions in case of prognostic models (e.g., 3-year overall survival).
7	Statistical model or algorithm used (e.g., logistic regression, Cox regression, random forest, or neural network) and approach for internal validation (for development studies).
Results	
8	Number of participants and outcome events.
9	Predictors in the final model (for development studies).
10	Performance measures, at least calibration and discrimination (with CIs), and results for added value of predictors or for model updating, if applicable.
Discussion	
11	Overall interpretation of the results, including implications for practice or research.
Registration	
12	Registration number and name of registry or repository.

combination of these elements), the target population, and the outcome to be predicted.

Only 12% of the 170 reviewed studies described the type of prediction model study in the title (**Supplement Table 1**, available at Annals.org).

Background

Item 2: A brief explanation of the health care context (including whether diagnostic or prognostic) and rationale for developing, validating, or updating the model.

Example

> Infectious endocarditis (IE) in febrile injection drug users (IDUs) is a critical diagnosis to identify in the emergency department (ED). A decision tool that identifies patients at very low risk for endocarditis using readily available clinical data could reduce admissions and cost (9).

Explanation

An explanation of the health care context and rationale for the study helps readers understand the intended use of the model.

Objectives

Item 3: Study objectives, including whether the study describes the development, validation, or updating of a model. For validation of an existing model, give the name or describe the model being validated.

Example

> To evaluate the diagnostic performance of a previously derived decision instrument to rule out endocarditis in febrile IDUs (Prediction Rule for Endocarditis in Injection Drug Users [PRE-IDU]) and to develop a prediction model for likelihood of endocarditis for those who are not ruled out by PRE-IDU (9).

Explanation

Study objectives should make clear whether the study describes the development, validation, or updating of a model. If an existing model is being validated, the objectives should include that model's name or description to facilitate identification of all studies involving that model.

Study objectives were clearly reported in 76% of the publications in our review (**Supplement Table 1**).

Methods

Item 4: Study design or source of data (for example, cohort, registry, routine care data, or randomized trial), separately for the development and validation data sets, if applicable.

Example

> We performed a prospective cohort study of all trauma patients admitted to our emergency room over a 1-year period to evaluate the utility of this tool for emergency physicians to detect significant haemorrhage in the trauma patient (10).

Item 5: Participant eligibility criteria and setting where the data were collected.

Example

> The Women's Health Study (WHS) is a nationwide cohort of US women free of cardiovascular disease, cancer, or other major illness at baseline from 1992 to 1995. A total of 27 542 women ages 45 to 79 years with complete ascertainment of plasma lipids and other risk factors were followed for a median of 10 years (11).

Item 6: Outcome to be predicted by the model, including time horizon of predictions in case of prognostic models (for example, 3-year overall survival).

Example

> The outcome was 5-year all-cause mortality (12).

Explanation

Including the study design or data source (item 4), participant eligibility criteria and setting (item 5), and outcome to be predicted (item 6) provides insight into the prediction model's applicability and generalizability. Describing the data source also helps the reader judge risk of bias, which varies with study design (13, 14). In addition, the predictive ability of a model depends on the predicted outcome and prediction horizon.

Of the 170 reviewed models, 69% reported setting, 76% study design or data source, 78% study participants, and 95% predicted outcomes (**Supplement Table 1**).

Item 7: Statistical model or algorithm used (for example, logistic regression, Cox regression, random forest, or neural network) and approach for internal validation (for development studies).

Examples

> In this retrospective cohort study, 6-month, 1-year, and 2-year mortality prediction models with recurrent neural networks used patient demographic information and topics generated from clinical notes within Partners HealthCare System. . . . The models were trained using a data set of 24 229 patients and validated using another data set of 2692 patients (15).

> Prognostic models were developed using proportional odds ordinal logistic regression using patient characteristics and baseline and 3-month

patient-reported outcome scores. Models were fit for each outcome stratified by type of surgical procedure. . . . Models were internally validated using bootstrap resampling (16).

Explanation

The full text of a publication about a prediction model study should contain enough details about the statistical model to allow the reader to understand and verify the approach taken. In contrast, the abstract should just make clear what statistical model or algorithm was applied and, for model development and updating, the approach for internal validation (item 7). Internal validation is important for assessing overfitting of the developed or updated model and adjusting for optimism in model performance (17–19). Reporting this essential step in the abstract helps the reader judge the study's risk of bias (13, 14).

About half (53%) of the models in the review reported the statistical methods used for model development or validation (**Supplement Table 1**).

Results

Item 8: Number of participants and outcome events.

Example

The derivation and validation cohort consisted of 240 and 793 patients with [chronic obstructive pulmonary disease], of whom 29% and 28%, respectively, experienced an exacerbation during follow-up (8).

Explanation

The numbers of participants and outcome events are important for interpreting a prediction model's precision and the risk of bias in its performance estimates (13, 14). The smaller the sample size—and particularly the fewer the study participants with the outcome—the higher the risk of bias in the estimates of a model's predictive performance measures.

Overall sample size and number of participants with the outcome were reported for 94% and 49%, respectively, of the 170 assessed models (**Supplement Table 1**).

Item 9: Predictors in the final model (for development studies).

Example

The final model included four easily assessable variables: exacerbations in the previous year, pack years of smoking, level of obstruction, and history of vascular disease (8).

Explanation

For development studies, the abstract should report which predictors were included in the final model. If predictors are too numerous to list in an abstract, authors can instead describe predictor categories (for example, sociodemographic predictors, history-taking and physical examination items, laboratory or imaging tests, and disease characteristics).

Predictors in the final model were reported for 63% of the model development studies in our review (**Supplement Table 1**).

Item 10: Performance measures, at least calibration and discrimination (with CIs), and results for added value of predictors or for model updating, if applicable.

Example

The ADO score was discriminatory for predicting 3-year mortality (AUC = 0.74; 95% CI: 0.69–0.79). Similar performance was found for 1- (AUC = 0.73; 0.66–0.80) and 2-year mortality (0.72; 0.67–0.76). The ADO score showed reasonable calibration for predicting 3-year mortality (calibration slope 0.95; 0.70–1.19) but over-predicted in cases with higher predicted risks of mortality at 1 (0.79; 0.45–1.13) and 2-year (0.79; 0.57–1.01) mortality (20).

Explanation

The abstract for a prediction model study should include model performance results (item 10). At least calibration and discrimination (with CIs) should be presented (preferably the optimism-corrected performance measures) because these are the 2 key aspects for characterizing prediction model performance. The results of the added value of predictors and model updates should be reported (for example, increase in c-statistic of the model after adding predictors or updating the model) if this was undertaken. Some measures, like calibration, are often presented graphically; however, they can be quantified, such as with calibration slope or calibration in the large. We suggest that authors preferably report these quantitative calibration measures in the abstract. If allowed, such as in conference abstracts, a graph could also be included.

Discrimination performance measures were reported more often (44% of 170 models) than calibration measures (11%) (**Supplement Table 1**).

Discussion

Item 11: Overall interpretation of the results, including implications for practice or research.

Example

The pooled cohort risk score appears to overestimate [cardiovascular] risk but this apparent over-prediction could be a result of treatment. In the absence of a validated score in an untreated population, the pooled cohort risk score appears to be appropriate for use in a primary care setting (21).

Explanation

A brief concluding statement of the overall interpretation of the results, including main limitations and

implications for clinical practice or research (item 11), enables readers to consider how the results apply to them.

Main conclusions were reported in 91% of the 170 assessed models (**Supplement Table 1**).

Registration

Item 12: Registration number and name of registry or repository.

Examples

> [A] large prospective cohort study (PREP-946) for development of prognostic models . . . Trial registration: ISRCTN40384046 (22).
>
> We developed a simple/practical scoring rule (logistic regression model) for recurrent [*Clostridium difficile* infection] using data from 2 large phase 3 clinical trials. . . . Clinical Trials Registration: NCT00314951 and NCT00468728 (23).

Explanation

Although registration of prediction model studies is not yet common practice, it is helpful to indicate the availability of a study protocol or data in a register or repository and provide relevant registration numbers for abstract readers. The first example reflects the reporting of a registered prediction model study. In the second example, the authors refer to 2 registered randomized trials from which data were used to develop a prognostic prediction model for risk for recurrence of *C difficile* infection in patients recently diagnosed with it.

DISCUSSION

Although abstracts cannot and should not replace full research reports in the communication of research findings, they have an important role in informing readers what was done. TRIPOD for Abstracts contains items that are considered essential for inclusion in all abstracts of prediction model studies. Although the checklist presents these items in the typical order of an abstract, how to incorporate them will depend on journal and conference requirements. They should be seen as the minimum set of information that is required for informative abstracts on prediction models.

During the development of TRIPOD for Abstracts, several survey respondents expressed concerns about the limited space typically allowed for abstracts. Although it is challenging, we believe that all of the essential information can be provided in 250 to 350 words, as shown by the examples of adequate reporting in Part 3 of the **Supplement**.

Without complete reporting of a study, the efforts spent in conducting the research can be considered wasted (24). This also includes reporting in titles and abstracts. We developed this extension of the TRIPOD statement to improve the reporting of prediction model studies in abstracts. For other study designs, the introduction of reporting guidelines for abstracts led to more thorough reporting, although room for improvement remained (25–30). Although primarily targeted at researchers, reporting guidelines can also be used by peer reviewers and journal editors to check reporting completeness and prevent the publication of poorly reported research.

TRIPOD for Abstracts will contribute to improved reporting in abstracts and thereby help readers and reviewers to identify prediction model studies that may be relevant and to assess the applicability and validity of the findings from abstracts, thus ensuring that they can take full advantage of the available evidence from this type of study.

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