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Clinical calculators in hospital medicine: Availability, classification, and needs

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ABSTRACT

Objective: Clinical calculators are widely used in modern clinical practice, but are not generally applied to electronic health record (EHR) systems. Important barriers to the application of these clinical calculators into existing EHR systems include the need for real-time calculation, human–calculator interaction, and data source requirements. The objective of this study was to identify, classify, and evaluate the use of available clinical calculators for clinicians in the hospital setting.

Methods: Dedicated online resources with medical calculators and providers of aggregated medical information were queried for readily available clinical calculators. Calculators were mapped by clinical categories, mechanism of calculation, and the goal of calculation. Online statistics from selected Internet resources and clinician opinion were used to assess the use of clinical calculators.

Results: One hundred seventy-six readily available calculators in 4 categories, 6 primary specialties, and 40 subspecialties were identified. The goals of calculation included prediction, severity, risk estimation, diagnostic, and decision-making aid. A combination of summation logic with cutoffs or rules was the most frequent mechanism of computation. Combined results, online resources, statistics, and clinician opinion identified 13 most utilized calculators.

Conclusion: Although not an exhaustive list, a total of 176 validated calculators were identified, classified, and evaluated for usefulness. Most of these calculators are used for adult patients in the critical care or internal medicine settings. Thirteen of 176 clinical calculators were determined to be useful in our institution. All of these calculators have an interface for manual input.

1. Background

Clinical calculators are widely used in modern clinical practice, but are not generally applied to electronic medical record (EHR) systems. One reason for widespread use of clinical calculators in modern clinical practice is increased ease of accessibility to computers, including desktops, laptops, smartphones, and tablet/handheld computers [1]. Other potential reasons include: the reliance of evidence medicine-based practice on quantitative metrics to guide decision making (e.g. CHADS score for atrial fibrillation stroke risk); patient

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standardization to facilitate administrative and research transactions (APACHE standardized mortality ratio); and quality improvement tracking. However, the use of clinical calculators by providers has not directly translated to widespread integration of these clinical calculators into existing EHR systems.

The clinical decision-making process, based on an algorithmic approach, ensures a standard of care appropriate to a clinical problem [2]. This approach has been shown to be beneficial across multiple fields of medicine [3–5]. The application of this approach in the clinical decision-making process implies the use of large computerized datasets [6,7], and has led to the development, introduction, and utilization of clinical calculators. Clinical calculators can exist as hardware or software [8,9]. Hardware clinical calculators, such as glomerular filtration rate and body surface area, are still used by clinicians. Software clinical calculators exist as standalone software, mobile device apps, and EHR-based software.

Clinical calculators have also been used for quality improvement and administrative/financial management. The widespread use of mobile devices has created a business niche for healthcare applications and generated increased academic interest in these technologies [10]. Clinician use of handheld computers with decision support tools and calculators has been shown to improve the clinical decision-making process [11]. The choice of calculator should be based on its clinical relevance—the right tool for the right person in the right context. However, important barriers to the application of these clinical calculators into existing EHR systems include the need for real-time calculation, human–calculator interaction, and data source requirements. The objective of this study was to identify, classify, and evaluate the use of available clinical calculators for clinicians in the hospital setting.

2. Methods

2.1. Study design and setting

This is an observational study performed at Mayo Clinic in Rochester, Minnesota. This study was exempted from institutional review board approval.

2.2. Data sources

Dedicated online resources with clinical calculators and providers of aggregated medical information were used (UpToDate, Merck/Univadis, and Medscape) [12–14]. Names of available clinical calculators were extracted. Resources and web pages hosted on anonymous platforms (without references, contact information and disclaimers), containing a catalogue of external links, or reproducing existing resources) were excluded. To verify the clinical validity of each online calculator, at least one PubMed reference was required.

2.3. Calculator classification

Calculators were mapped by clinical categories, mechanism of calculation, and the goal of calculation. Three clinical categories were created: (1) age of target subjects (pediatric, adult, pediatric and adult, or geriatric); (2) primary medical specialty (anesthesiology, critical care, emergency medicine, internal medicine, obstetrics/gynecology, and surgery; and (3) medical subspecialty. Medicare Specialties Codes, National Uniform Claim Committee (NUCC) HealthCare Provider Taxonomy, and the American Medical Association (AMA) definitions of medical specialties were used to create clinical categories 2 and 3. The mechanism of calculation combined from one to multiple from the following: formula, rule, summation logic, cutoff, and regression. Based on initial source, the following goals of calculation were assigned to each calculator: decision, diagnostic, prediction, risk estimation, and severity.

2.4. Acquisition of usage data

Administrators of selected online resources were asked to provide monthly web statistics for presented calculators. The number of page visits during one month and the average time of session for each calculator were collected from the administrators of included online resources (Table S1). An online survey was created with calculators grouped by specialty, goal, and mechanism of calculation. Each calculator had a brief description, year of introduction, and PubMed ID. Invitations to take the survey were sent by email to a focus group of attending physicians at Mayo Clinic in Rochester, Minnesota. Calculators were evaluated by responders using 3-point scale: “Very important,” “Nice to have,” or “Don’t need.”

2.5. Statistical analysis

Descriptive statistics were used to summarize data sources and calculator types according to prespecified domains. Study data for the online survey were collected and managed using the REDCap electronic data capture tool hosted at Mayo Clinic in Rochester, Minnesota [15]. JMP Pro statistical software (SAS, Cary, NC) was used for all statistical analyses.

3. Results

More than 100 resources were identified, but only 28 met inclusion criteria (Fig. 1). Extraction of available calculators supplied us with 371 tools. One hundred ninety-five were excluded because they used simple formulae, equations, or conversion mechanisms.

For all 176 extracted calculators, a primary and validating source was available in PubMed. All identified calculators were defined in four categories, resulting in 63 groups. The majority of studied calculators were designated for the adult population in critical care, emergency medicine and internal medicine (Fig. 2).

The most frequent goal of calculation was prediction, followed by severity, risk estimation, diagnostic, and decision-making aid (Table 1). The most frequent mechanism of computation was a combination of summation logic with cutoffs or rules (N = 120; 68%). Regression analysis (iterative logic) was used in combination with all mechanisms of computation, but not for every case (N = 52, 30%). The number of