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Diffusion of Innovations model helps interpret the comparative uptake of two methodological innovations: co-authorship network analysis and recommendations for the integration of novel methods in practice

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Abstract

Objective: The objective of this study was to characterize the diffusion of methodological innovation.

Study Design and Setting: Comparative case study analysis of the diffusion of two methods that summarize confounder information into a single score: disease risk score (DRS) and high-dimensional propensity score (hdPS). We completed systematic searches to identify DRS and hdPS papers in the field of pharmacoepidemiology through to the end of 2013, plotted the number of papers and unique authors over time, and created sociograms and animations to visualize co-authorship networks. First and last author affiliations were used to ascribe institutional contributions to each paper and network.

Results: We identified 43 DRS papers by 153 authors since 1981, reflecting slow uptake during initial periods of uncertainty and broader diffusion since 2001 linked to early adopters from Vanderbilt. We identified 44 hdPS papers by 147 authors since 2009, reflecting rapid and integrated diffusion, likely facilitated by opinion leaders, early presentation at conferences, easily accessible statistical code, and improvement in funding. Most contributions (87% DRS, 96% hdPS) were from North America.

Conclusion: When proposing new methods, authors are encouraged to consider innovation attributes and early evaluation to improve knowledge translation of their innovations for integration into practice, and we provide recommendations for consideration.

Key Words: Bibliometrics; Diffusion of innovation; Disease risk score; Pharmacoepidemiology; Social networks; Propensity score; Methodological innovation

1. Introduction

The field of postmarketing drug safety and effectiveness research (pharmacoepidemiology) has experienced rapid scientific progress and growth [1,2], particularly in the last decade [3−6]. The rapid increase may partly relate to the emerging availability of health care utilization data [7,8] and significant funding investment [9,10]. The recent investment in pharmacoepidemiology is motivated by the recognition that drug safety and efficacy data from randomized controlled trials are limited [2], and thus, more evidence is needed for postmarketing to improve our understanding of drug benefits and harms [7]. Real-world drug safety and effectiveness data are important for patient and physician prescribing decisions, as well as for drug policy decision making. Methodological challenges in pharmacoepidemiology have required innovative solutions. Prior research has identified slow knowledge translation of statistical innovations [11,12]. We identified two statistical innovations that summarize confounder information into a single score: disease risk score (DRS [13]) and high-dimensional propensity score (hdPS [14]) to serve as

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What is new?

- When proposing new methods, authors are encouraged to consider innovation attributes and early evaluation to improve knowledge translation, and thus integration of their innovation(s) into practice; and we provide recommendations for consideration.
- Co-authorship network analysis can be used to examine the diffusion of methodological innovation by visualizing the prominence of, and connections between authors that publish using novel methods.
- We propose methods to ascribe institutional credit to publications and encourage researchers to consider and comment on our approach.
- Web of Science citation and author searches are important to help find the application of innovative methods, as keyword searches are limited.

comparative case studies in the diffusion of methodological innovation. Our aim was to examine the speed (number of publications over time) and spread (across institutions) of each innovation and interpret uptake relative to innovation attributes, the social system, and communication channels described in Rogers' Diffusion of Innovations model [15].

2. Methods

We apply comparative case study methods with the Diffusion of Innovations model [15–18]. In brief, the Diffusion of Innovations model defines diffusion as a process by which an innovation (something perceived as new) is communicated through channels (how messages are passed between individuals) over time among members of a social system, Box 1. In particular, the rate of adoption of an innovation is proposed to be affected by five innovation attributes: (1) relative advantage over existing ideas or methods, (2) compatibility with the needs and values of potential adopters, (3) complexity (hereafter referred to as simplicity), (4) trialability (degree it can be tested), and (5) observability (degree its use and results are visible to others) [15].

We selected two methodological innovations in pharmacoepidemiology that cover a range of innovation attributes and time frame within a social system, according to the Diffusion of Innovations model, Table 1.

2.1. Case study 1: disease risk score

Stratification or matching by confounding variables was a common approach to control for confounding in the 1970s. However, stratification becomes inefficient as the number of strata or confounding variables to control for increases. The DRS, proposed by Miettinen in 1976 (''multivariate confounder score'') [13], summarizes all confounder information into a single summary score. Authors can then use DRS for stratification and thus reduce the number of strata. The innovation addressed an important limitation at the time and had a clear advantage over traditional stratification by individual confounding variables (relative advantage). Because the DRS is based on the baseline probability of disease risk, it can also be used to provide a meaningful scale to examine effect modification [19–21]. Despite its advantages, a recent systematic review (from 1976 to May 2011) identified that DRS initially received little attention or application in the epidemiologic literature [6]. DRS application was characterized by a bimodal distribution with a peak in 1979/1980 and resurgence since 2000 [6]. DRS was first proposed in 1976 [13], yet a simulation paper published in 1979 introduced early uncertainty in the method by concluding that it overestimates confounding and thus induces bias [22]. A subsequent simulation published in 1989 concluded that overestimation of confounders was rare [23], and more recent contributions corroborate DRS ability to control for confounding and highlight its potential advantages [19–21,24,25]. This case study thus provides an opportunity to consider the diffusion of an innovation introduced during the infancy of the field of pharmacoepidemiology and over a 40-year time span in the context of initial uncertainty.

2.2. Case study 2: high-dimensional propensity score

Studies that rely on health care utilization (administrative claims) databases may be biased if important confounding information is missing. In theory, statistical adjustment for proxy variables or combinations of variables that indirectly capture information on unmeasured confounder(s) may yield better control for confounding. The hdPS is an adaptation of the commonly used propensity score [5] and uses a multistep algorithm to empirically identify candidate proxy variables based on their estimated strength of confounding. The proxy variables are then included into the hdPS [14]. The innovation paper included simple figures to help contextualize the theory around proxy variables (simplicity), compared statistical adjustment using a standard confounder model to that using the hdPS (compatibility), documented results closer to those from clinical trials when using the hdPS (advantage), and authors posted statistical code on their research website (www.drugepi.org/dope-downloads/) to facilitate application of the innovation by other researchers (trialability). In addition, preliminary results were presented at the International Society for Pharmacoepidemiology meeting (observability and active communication channel), the first author (Schneeweiss) served as the president of the