

A mental health clinician's primer on statistical mediation and moderation

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ABSTRACT

Statistical literacy is vital to the effective delivery of evidence-based mental healthcare. In this context, mediation and moderation models of mental processes have become increasingly popular, because of their potential to reveal possible causal mechanisms between variables or specific conditions for a given effect to occur. This brief article aims to introduce practicing mental health clinicians to statistical mediation and moderation models, by outlining their conceptual distinction, summarizing the underlying data analysis procedures, and discussing the implications of such models for clinical decision making in mental health practice.

Introduction

Mediation and moderation models of mental processes have become increasingly popular, because they allow the decomposition of interesting associations between variables in ways that reveal possible causal mechanisms or specific conditions for a given effect to occur [1,2]. The utility of mediation and moderation analyses stems from their capacity to go beyond the merely descriptive to a more functional understanding of the relationships among variables [3]. Therefore, these statistical models are particularly useful for theory testing and development as well as for the identification of potentially modifiable links that can be targeted in clinical practice [2].

In fact, mental health professionals should cultivate not only clinical knowledge and skills, but also statistical literacy (i.e. one's ability to critically appraise and apply clinical research literature) to provide optimal evidence-based care [4]. This brief article aims to introduce practicing mental health clinicians to the statistical reasoning underlying mediation and moderation models, mostly in nonmathematical terms, while illustrating the utility of such analytical models for informing evidence-based clinical practice.

What is mediation?

Mediation analysis seeks to specify through which mechanisms a given effect occurs between an independent variable and a dependent variable [5]. According to MacKinnon and colleagues [6], "a mediating variable transmits the effect of an independent variable on a dependent variable" (p. 593). Since mediation analysis implies a sense of causality between a sequence of variables, it should be preferably examined in longitudinal research; nevertheless, theory-driven cross-sectional mediation studies often provide useful insights on potential mechanisms that can be subsequently reexamined in more sophisticated research designs [7].

Types of mediation and clinical meaningfulness

There are essentially three types of mediation, depending on the number and ordering of the tested mediators. In simple mediation, a single mediator is tested in linking an independent variable to a dependent variable (see Panel A, Figure 1). For instance, post-traumatic stress disorder (PTSD) was found to mediate the relationship between childhood trauma and later psychotic experiences (proportion mediated of 14% in adolescents). This result suggests that treating PTSD symptoms may prevent or mitigate the effects of childhood trauma on the development of psychotic outcomes [8].

In parallel multiple mediation, two or more mediators are simultaneously examined in transmitting the effects of an independent variable on a dependent variable (see Panel B, Figure 1). For example, self-compassion, emotional dysregulation, and psychological flexibility were reported to mediate the link between mindfulness and psychological well-being (with standard estimates of indirect effects being progressively higher for emotional dysregulation, cognitive flexibility, and self-compassion) [9]. In practice, this finding

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suggests that mindfulness-based interventions may improve adolescent mental health outcomes through the enhancement of self-regulatory skills.

In serial mediation, two or more mediators are thought to operate sequentially, with a given mediator potentially influencing the next mediator in a chain (see Panel C, Figure 1). For instance, thought suppression and self-compassion were found to mediate, in sequence and at an exploratory level, the association between insecure attachment and depression; moreover, this serial model of mediators in chain displayed a higher effect size than each single mediator model alone. The immediate implication of this finding for the practicing clinician is that individuals with an insecure attachment style are prone to adopt thought suppression strategies, which may in turn limit their ability to engage in self-compassionate responses and thus ultimately increase their depression levels [10].

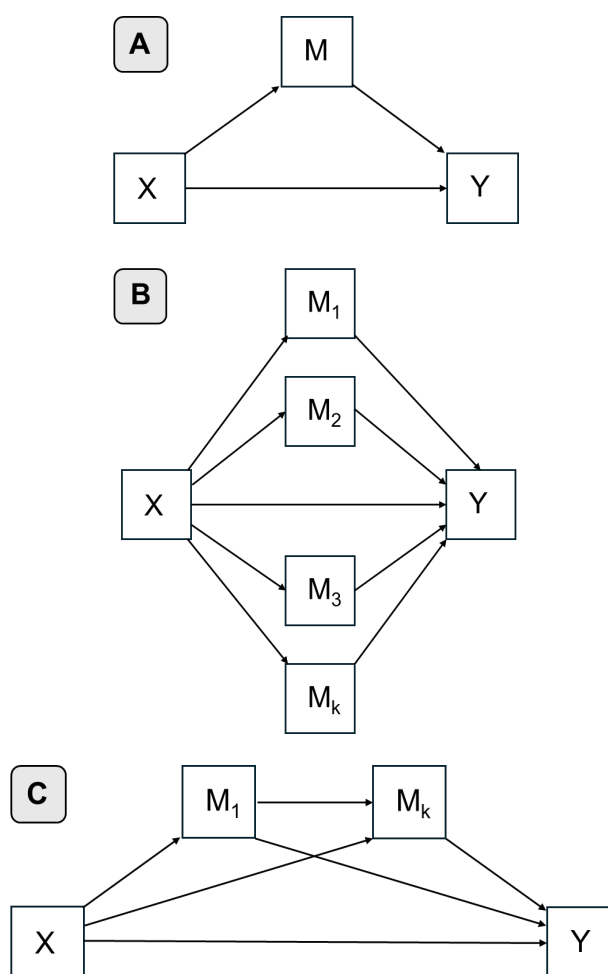


Figure 1 - Graphical depictions of simple (Panel A), parallel multiple (Panel B) and serial multiple (Panel C) mediator models (adapted from [1]). Note: X = independent variable (predictor); Y = dependent variable (criterion); M = mediating variable.

What is moderation?

A moderator is defined as a qualitative (e.g., sex) or quantitative (e.g., level of social support) variable that affects the strength and/or direction between an independent variable (predictor) and a dependent variable (criterion) [11]. While mediation seeks to answer the questions of “how?” or “through which mechanisms?”, moderation seeks to answer the questions of “for whom?” or “under what circumstances?”. Therefore, moderator variables are especially important to identify specific factors that can reduce or augment the influence of the independent variables on the dependent variable (e.g., an intervention may work differently for men or women, or for subgroups of patients with different comorbidity patterns).

As regards conditional effects of gender, for instance, the association between emotional distress and negative drinking consequences has been found to be stronger among men than women [12]. This finding indicates that men may be at greater risk than women of experiencing negative alcohol-related consequences, thus informing the clinician about gender-related specificities when assessing and managing emotional drinking in their practice.

Moderation is also useful to address the common question of “why do some individuals develop psychopathology in response to adversity, and others do not?”. When reviewing risk and resilience factors that conditionally affect (i.e., moderate) the relationship between child trauma exposure and psychopathology, McLaughlin and Lambert [13] noted that children who had supportive caregivers were less likely than their counterparts to develop psychopathology following trauma exposure. Accordingly, a major implication of this finding is that ensuring the availability of positive relationships with caregivers may buffer the impact of trauma exposure on children’s mental health.

Clinical meaningfulness of moderation analyses

In intervention research, moderation analyses are crucial do identify those variables (e.g., symptom severity, symptom constellation) that may affect treatment response differentially across subgroups. For instance, cognitive-behavioral therapy (CBT) combined with medication was found to have treatment superiority over medication alone in depressed adolescents who had more comorbid disorders (particularly anxiety disorders), in comparison to those who had fewer or no comorbid disorders [14].

In risk and protective factor research, the clinical interpretation of moderators will depend on the specific circumstances under which the conditional effects were found to occur. This interpretation, based on the premises of developmental psychopathology, has been clearly outlined by Rose and colleagues [15], and is now summarized in Table 1.

Table 1 - Definitions of possible moderating effects in risk and protective factor research (adapted from [15])

Term	Definition
Protective factor	A variable that decreases the likelihood of a negative outcome under adverse conditions.
Resource factor	A variable that positively influences outcome, regardless of the presence of adversity.
Vulnerability factor	A variable that increases the likelihood of a poor outcome under adverse conditions.
Risk factor	A variable that negatively influences outcome regardless of the presence of adversity.

Conducting mediation and moderation analyses

The classical statistical approach to regression-based mediation and moderation analyses [11] can be easily performed using two online programs (i.e., MedGraph and ModGraph), which provide step-by-step descriptions of the statistical procedures to be performed [16,17]. These online programs are very intuitive to use and quickly provide graphical depictions of mediation and moderation among three variables. Nevertheless, the classical approach to mediation analyses typically requires large sample sizes and tends to have low statistical power [6].

The contemporary approach to regression-based mediation and moderation analyses draws heavily on bootstrapping procedures (e.g., path analysis, regression with latent variables, such as in structural equation modelling). Bootstrapping is a nonparametric resampling procedure that does not require the assumption of normality of sample distribution and involves repeated sampling from the data set to estimate the indirect effects in each resampled data set, while having good statistical power and maintaining reasonable control over the Type-I error. Based on bootstrapping procedures, the PROCESS macro is a free access computational tool that can be easily incorporated into the SPSS or R commands (other options include, for example, user-friendly R packages [18]), enabling a streamlined computation of mediating and/or moderating effects. The handbook that elaborates on this approach provides a comprehensive guidance for testing a variety of mediation- and/or moderation-based statistical models (currently, more than 90 models on mediation, moderation, and conditional process analysis): for instance, simple moderation, parallel mediation (with one or more mediators), and serial mediation (all mentioned above) are respectively depicted in model 1, model 4, and model 6 of the command guide that integrates the handbook. As all these models are essentially regression-based (i.e., a linear regression model is an equation that links one or more input variables to an output variable by exploring information contained in the correlation between inputs and output), this fundamental handbook provides detailed descriptions and explanations of the mathematical equations underlying the computation of such models [19].

Finally, it is worth noting that, when the assumptions for the interpretation and statistical inference of regression-based models (i.e., linearity, normality, homoscedasticity, independence) [19, 20] are not duly met, the alternative semiparametric or nonparametric bootstrapping procedures may be adopted to efficiently estimate mediation effects [21, 22].

Conclusions

Clinicians who are cognizant of mediation and moderation studies in mental health research are likely best equipped to outline theory-driven and evidence-based case formulations or intervention plans. Being knowledgeable about these statistical procedures will broaden the clinician's understanding of developmental and etiological pathways, mechanisms of change in psychiatric treatments, or idiosyncratic variables affecting treatment response. As mediation and moderation models have become increasingly complex over the last couple of decades (e.g., moderated mediation, moderated moderation, mediation and moderation models in two-condition repeated measures designs), there is good reason to expect that mediation and moderation research designs will continue to go hand in hand with evidence-based decision making in mental health clinical practice.

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