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Review Article

Identifying and analyzing variables in musculoskeletal healthcare research

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ABSTRACT

This review intends to help the students and researchers to organize, write, and analyze to make a quality research paper and to know the importance of variables in healthcare clinicians/researchers. Variables are fundamental components of the research question, serving as properties that distinguish members of groups or sets. They explain the different aspects of the sample that is under study. Variables are capable of having multiple values. Variables vary from subject to subject in the sample. A variable is a fundamental concept in research, representing a concept, image, or perception that can take different measurable values. Research design (RD) involves comparing independent groups or conditions, exploring predictive relationships, experimental studies for causal links, and comparative studies with multiple independent variables (IVs) or dependent variables (DVs). Variables play a crucial role in research and are broadly classified into causal relationships, study design, and units of measurement. IV is predictors that influence outcomes known as DV. Extraneous variables are unrelated but impactful. Moderating variables alter the relationship between IV and DV. Intervening variables or confounding variables (CVs) can complicate the cause-and-effect relationships. Active variables are manipulated, while attribute variables, inherent traits such as age, cannot be controlled. Even tests are based on variables. This review provides a comprehensive guide for students and young researchers to understand the role of variables and RD in conducting quality research papers, emphasizing the importance of operationalizing variables, controlling for CVs, and selecting appropriate RDs.

Keywords: Confounding variables, Dependent variables, Exercise therapy, Independent variables, Research design, Variables

INTRODUCTION

Variables are fundamental components of research questions, serving as properties that distinguish members of groups or sets.[1] They can be considered concepts or factors capable of having multiple values.[2] By definition, variables change or vary, making them distinct from constants. A factor transforms into a variable when utilized specifically within a study.[2-4] For example, comparing low back pain (LBP) levels between males and females would make both pain and sex variables because they possess varying values. However, if a study compared the effectiveness of two treatments for reducing LBP in males solely, sex would not be considered a variable since its value remains constant across all participants. In descriptive and correlational studies, researchers observe and analyze the characteristics of variables separately and explore

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their relationships.[5] The studies aim to understand how variables exist naturally or to identify patterns among them. Conversely, exploratory and experimental studies investigate cause-and-effect relationships among variables to forecast results or demonstrate that one variable impacts another.[1] Researchers typically classify variables in such studies as either independent or dependent. The experimenter manipulates independent variables (IVs) and serves as causes, whereas dependent variables (DVs) are measured and reflect changes due to the influence of IV.[6]

Research endeavors are undertaken to explore the connections between variables or to elucidate their presence in the natural world. In descriptive and correlational studies, variables serve as representations of the phenomena under investigation, with their measurement taking various forms.[7,8] Researchers meticulously examine these characteristics individually, detailing their values and interrelations. In exploratory and experimental studies, investigators delve into the interactions among two or more variables to make predictions about outcomes or establish causal relationships.[6] In such studies, research variables are commonly categorized as IV or DV based on their roles within the research design (RD).[1] IV is those that are manipulated or controlled by the researcher to observe their impact on other variables.[1,9] They are often considered the cause in a cause-and-effect relationship. On the other hand, DV is measured or observed to assess changes resulting from IV manipulation. They are typically seen as the effect or outcome of a study.[1] Understanding the distinction between the IV and DV is crucial for designing robust research studies that can provide meaningful insights into relationships and phenomena under investigation.[1,2,10]

Variables also play a crucial role in healthcare clinicians and influence various aspects of patient's health and outcomes. There are various variable types in healthcare professionals' research, such as educational and professional, clinical to improve the quality of life, and many more. The relationship between the values and leadership has been found to affect the quality of patient care provided by professional healthcare/researchers. For instance, the relationship between values, leadership, satisfaction, and the work environment has been found to affect the quality of patient care provided by professional healthcare clinicians/researchers. Understanding different types of variables such as independent, dependent, control, extraneous, confounding, intervening, moderator, quantitative, and qualitative variables is essential for healthcare professionals to conduct research and interpret study results accurately.[1,3,6,11] Factors such as the healthcare environment, patient population, and adherence to regulatory standards can also influence clinical practice and patient care outcomes. Variables can impact healthcare practice and patient outcomes in various ways, such as pain assessment, medical history, and assessing outcome measures. Healthcare professionals must have a solid understanding of study design and variable classifications to appropriately select statistical tests for deriving meaningful outcomes. Knowing the types of variables will help them determine the types of variables and commonly used designs they need. By understanding the types of variables and commonly used designs, healthcare providers can conduct research and choose an appropriate design to avoid erroneous results, resulting in unsafe practices. This article aimed to comprehensively explore and analyze the importance of variables on healthcare clinicians/researchers.

DEFINITION

A variable is a concept, image, or perception capable of taking different values that can be measured, evaluated, and described in detail.[1-3] It is a fundamental building block of the research question.[3] In research terminology, it plays an extraordinary role; change/predictor variables are known as IV, and effect or variable is called DV.[7] When variables are not accounted for in the cause-and-effect relationship, they are referred to as extraneous variables (EVs). In contrast, those variables that mediate cause-and-effect relationships are termed intervening relationships.[1,6,10]

TYPES OF VARIABLES

Variables can be classified in several ways. Broadly, the variables are classified in three different ways: Casual relationship, study design, and unit of measurement [Figure 1].[1,2,6]

The causal relationship

In studies investigating associations, four sets of variables may be involved:

- Change variables instigate the alterations in a phenomenon, situation, or circumstance
- Outcome variables (OVs) signify the effects, impacts, or repercussions of a change variable
- Variables influencing the connection between cause-and-effect variables
- Connecting/linking variables play a crucial role in finalizing the relationship between the "cause-and-effect" variables in any given scenario.

IV And DV

The IV is the predictor variables. They can also influence other variables.[1] IV represents any condition, intervention, or characteristic capable of predicting or causing a specific outcome. Conversely, the OV, also known as the DV, is defined as a variable whose value depends on or is a consequence of another variable. Therefore, the variable preceding the DV is termed the IV.[1-3,7,10,12]

The operational definition (OD) should be sufficiently detailed so other researchers can replicate the condition/procedure. IV is operationally defined as operationalized accordingly, how

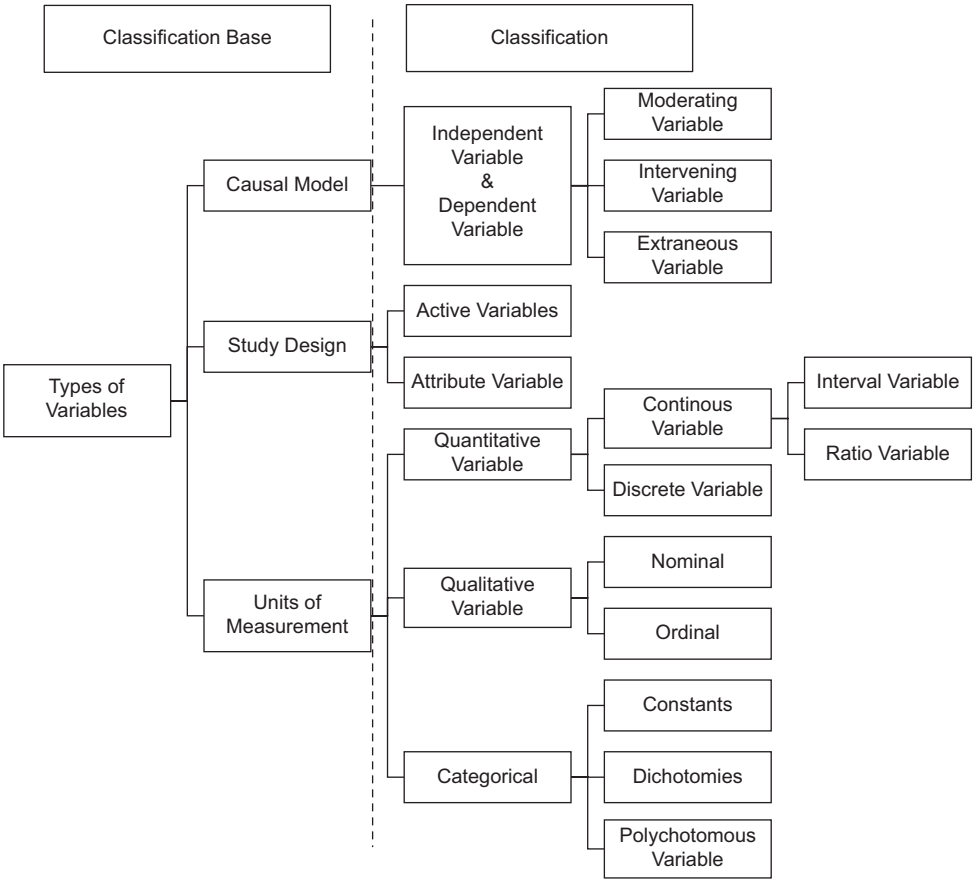

Figure 1: Types of variables.

they are manipulated by the researcher/investigator.[1,3] For example, a therapist prescribes a group of resisted exercises to gain strength in the biceps muscle. In this scenario, the IV will be the resisted exercises, which can be manipulated to observe their effects on the DV, i.e., strength gain. The DV (strength gain) is the outcome that the researcher measures to determine if the IV has an effect.

OD is crucial in research as it provides clear and specific guidelines for measuring or assessing variables.[1,2,12] For example:

- Variable: LBP
- OD: Numeric pain rating scale (NPRS).

NPRS is commonly used to assess the intensity of pain. It typically consists of a scale from 0 to 10, where 0 represents no pain and 10 represents the worst pain. This OD ensures that researchers and readers clearly understand how LBP is assessed and measured in the study, facilitating transparency and reproducibility in research.

Moderating variable

The variable has enough strong conditional influence to modify the original relationship between the IV and DV.[7] It moderates the strength and the relationship between the dependent and IV. For instance, a study into the effect of quality of instruction on players' sports may have moderating variables like the player's interest. This implies that the students interested in a particular activity will likely perform better in-ground performance. In contrast, the other students without such an interest may not perform well, irrespective of how good the instructions are.

Intervening variable

Intervening variables are sometimes also known as confounding variables (CVs).[1] In definite conditions, the connection between DV and IV is contingent upon the presence of another variable. Only in the existence or occurrence of an intervening variable can the IV, or the cause, express itself.[1-3]

Active variables (AVs)

AVs are those influenced by the researcher/experimenter assigning subjects to IV levels.[1-3,5,6] For example, in any study where participants are assigned to receive the medication and the placebo, the treatment is an AV.

Attribute variable

The researcher cannot allocate subjects to groups; rather, they have to observe participants within their accepted groupings based on inherent characteristics. Attribute variables cannot be manipulated by the experimenter.[1] When studying the effects of one or more attribute variables, a research endeavor cannot be classified as a true experiment.[1,13] For instance, occupation serves as an attribute factor wherein subjects naturally belong to specific groups without the possibility of assignment.[1] Other pre-existing characteristics such as age, gender, and diagnosis also fall under attribute variables.[1,13] For instance, examining differences in posture and range of motion (ROM) across various age groups and between genders such as males and females highlights this. Since sex is an inherent attribute before the study, relationships can be observed, but the design lacks adequate control, thereby restricting the interpretation of cause and effect.

It is achievable to combine the attribute variable and the AV in a one or single study.[1,13] As an illustration, one could examine the impact of aerobic exercises on Type II diabetes mellitus alongside the influence of age. This could involve categorizing participants into four age groups, with each individual within a group randomly assigned to one of two intervention groups. Despite involving an attribute variable, this study qualifies as an experimental because the researcher has the freedom to manipulate the allocation of intervention levels for at least one IV.

Quantitative variable

Quantitative variables reflect the notion of magnitude. They represent the numerical (numbers) and the measurements,[14,15] e.g., when the therapist measures the shoulder's ROM with the goniometer and assigns a numerical value representing the degree of movement (quantitative variable). The quantitative variables are divided into two types: Discrete and continuous.

Continuous variables

They can assume any theoretical value within a defined numeric range.[5] An indefinite number of fractional values exists between any two continuous variable values. In reality, the accurate measurement of continuous variables is unattainable, constrained solely by the precision of the measuring instrument.[1,5,15] For instance, the ROM of a joint can be recorded as 50°, 50.4°, or even 50.2°, contingent upon the marking or gradation of the goniometer and the proficiency of the examiner.

Interval variables

Interval variables can be measured along a continuum in a scale. The feature/factor of rank order can be found in interval variables,[6] e.g., temperature (which could be measured in Celsius and Fahrenheit). The scale or outcome measure is not measured from the zero, instead it is measured from the normal established value. Like the normal body temperature is defined as around 98.6°F, and more than that will be accounted as pyrexia. A zero-degree Celsius (0°C) reading does not indicate a complete lack of temperature.

Ratio variable (RV)

The RV is the first and leading interval variable.[6] RVs have the features of order and magnitude. They also have true zero or absolute points. For example, RV includes the weight, height, and test scores of the subjects.

Discrete variable

If variables can only be shown as numbers and they are non-continuous (don't take all possible values in a range), they are called discrete variables. Discrete variables have specific, separate values, like whole numbers.[16] Discrete variables are those that can only be complete, whole units.[1,16] As an illustration, heart rate is always quantified in beats per minute rather than in fractions of beats. Qualitative variables also describe discrete categories, such as sex (male/female).

Qualitative and categorical variable

In several ways, categorical variables are similar to qualitative variables. Both variables use either an ordinal or nominal measurement scale. Still, some variances are observed.[17] For instance, it is possible to evolve classifications based on measurements derived from a continuous scale.

Overall, there is a nuance between categorical and qualitative and continuous and quantitative variables.[5] Categorical variables are examined/measured on ordinal/nominal measurement scales whereas the continuous variables are measured on an interval or ratio scale.[13]

The categorical variable is divided into three categories:[13,16]

(a) Constant variable: These variables have only one category or a single value. For example, the therapist repeatedly practices the same task under the same condition.
(b) Dichotomous variables are when qualitative variables have only two categories or two levels. They may have similar features to nominal variables in terms of not having any intrinsic variable, such as sex (male/female).
(c) Polychotomous variables: These variables have three or more values or categories of subsets, e.g., built (mesomorph, ectomorph, and endomorphic).

RD and variables

The RD can be configured to enable comparison between the independent groups of participants, or it may involve

comparing responses across the treatment conditions within each participant.[1] When the IV level is assigned to numerous groups with distinguishing attributes or AVs, the IV is regarded as an independent factor.[1,2,5] For instance, in a study comparing the impact of two types of mobilization on pain reduction and increasing ROM in patients with bilateral periarthritis, each type would be administered to distinct patient groups.[18] Hence, the variable "mobilization" constitutes an independent factor with two levels.[19] Similarly, if the study assesses the effects of mobilization between male and female participants, "sex" would also function as an independent factor.

In exploratory studies, the IV and DV are typically assessed simultaneously to determine if they exhibit a predictive correlation.[1] For instance, researchers have examined the connection between LBP and various factors such as age, sex, cognitive status, ambulatory status, analgesic use, osteoporosis, and osteoarthritis within a long-term care population. The DV, representing the outcome, was the presence of LBP, while the IV acted as predictor variables, including characteristics such as age, sex, and cognitive status. Such studies often encompass multiple IVs as researchers seek to discern the interconnectedness of different factors in explaining the OV.

Experimental studies entail comparing various conditions to explore causal relationships, wherein the IV is manipulated while the DV is measured.[1,2,20]

For example, researchers compared the effectiveness of core strengthening and usual medical care to assess if core strengthening was effective in relieving pain in patients with LBP. The study measured outcomes such as changes in disability scores and the pain scale ratings. In this scenario, the IV is core strengthening (intervention), while the two DVs are disability and pain scores (response). Any alteration in the DV is assumed to be influenced by the condition of the IV; in other words, the DV is contingent upon the state of the IV.

In comparative studies, the RD involves considering multiple IVs.[2] For instance, researchers may examine the patient's sex in addition to the intervention to determine whether the effectiveness of core strengthening varies between the sexes (males and females). In this case, there are two IVs: Type of intervention and sex. Furthermore, a study can encompass more than one DV.

Demographic variable

The variables are collected by the researcher to elucidate the nature and the distribution of the sample employed alongside inferential statistics. The variables such as age, sex, occupation, ethnicity, and socioeconomic measure. Descriptive statistics is often used in demographic variables. It may also enter into multivariate models for confounding and controlling effects.[21]

Levels of IV

In comparative studies, IV is described as "values" referred to as levels.[1] In research, the levels represent the groups of conditions under comparison. Each IV typically comprises a minimum of two levels. Unlike IV, DVs are not categorized into levels.[1] For instance, in the study comparing spinal extension and home care, the IV "intervention" has two distinct levels: Spinal extension and home care. If the study had incorporated additional interventions such as spinal manipulation, mobilization, or bed rest, it could alter the intervention variable's level count rather than the number of variables themselves.

Manipulation of the variables

Manipulating the variables involves intentionally setting specific experimental conditions (the IV) for at least one group of participants/subjects. This deliberate action is carried out by the researcher or experimenter. This process allows the researcher to control and study the effects of the manipulated variables on the DV.[1] The experimenter adjusts the IV levels by assigning subjects to different conditions. This typically involves providing the intervention to one group while refraining from doing so with another.[1,22] For instance, the researcher may wish to investigate the impact of medication on reducing hypertension. Subjects can be assigned to treatment and control groups, and their blood pressure changes can be measured after a period of receiving treatment or no treatment. It is feasible to manipulate either a single variable or multiple variables concurrently.

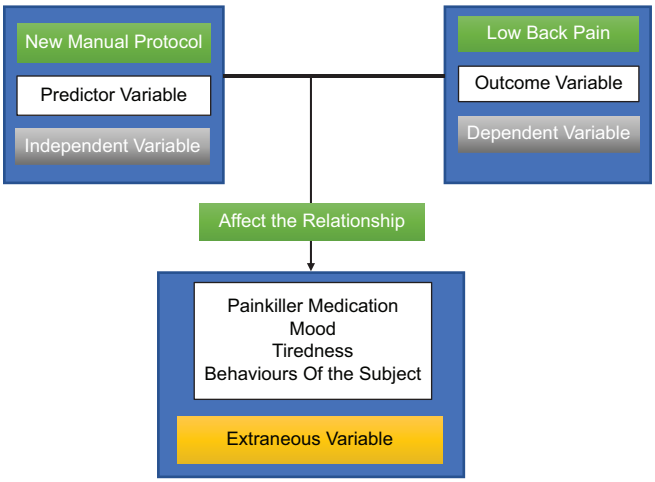

Figure 2: Extraneous variable could potentially affect the dependent variable.

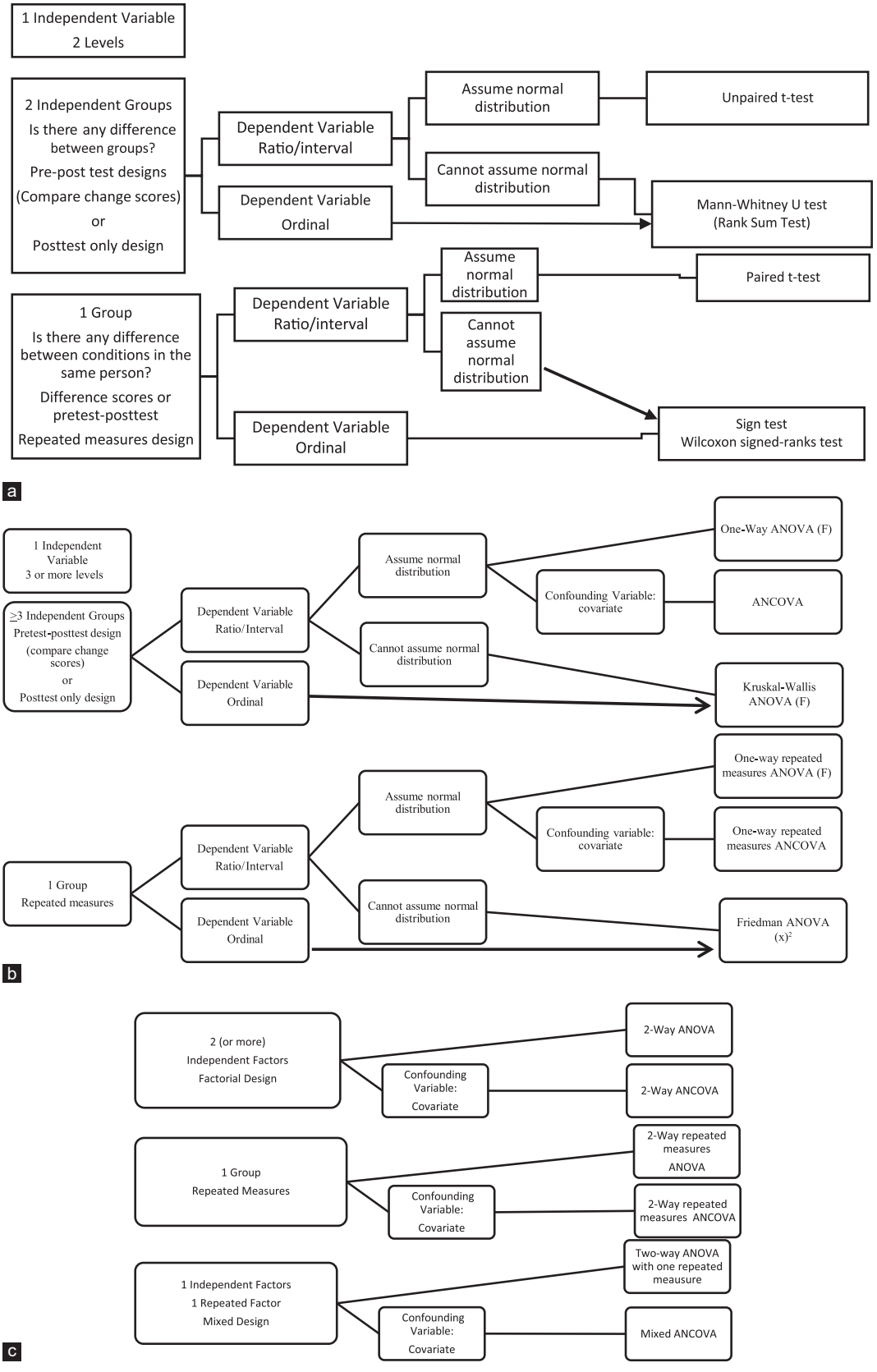

Figure 3: (a) The discrepancy in means (or medians) with single independent variable (IV), with two levels. (b) Difference between means (or medians) in 1 IV, >3 levels. (c) Two or more IV. ANOVA: Analysis of variance, ANCOVA: Analysis of covariance.

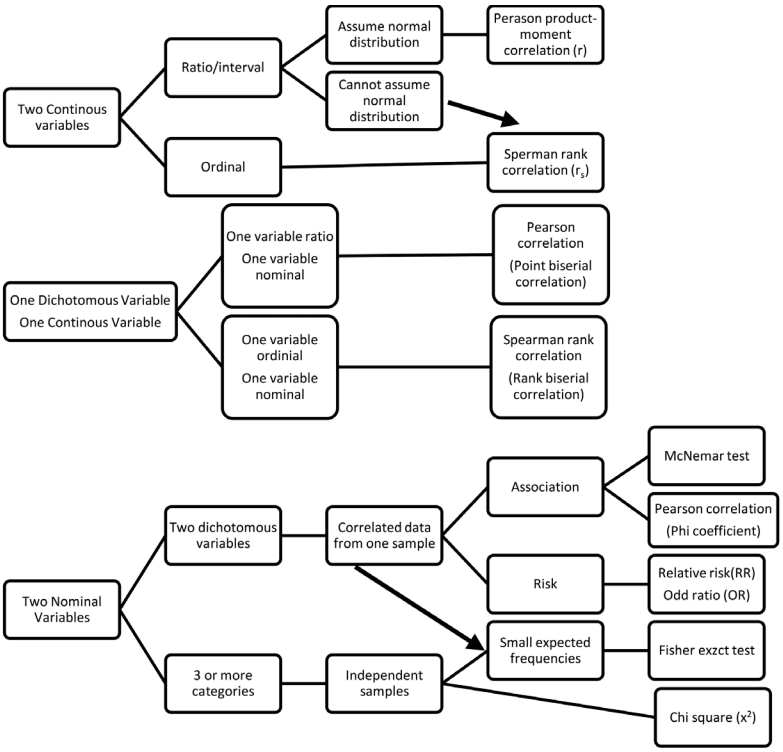

Figure 4: Association between variables.

EV

Factors not directly pertinent to the study's objectives but capable of influencing the DV are termed EVs.[14,17,23] It is also called "nuisance variables" or intervening variables.[5] EV could be external factors stemming from the environment and experimental conditions, as well as internal factors reflecting the personal characteristics of the study's subjects or participants.[1] For example, in a study, researchers are examining the effect of a new manual protocol for LBP. However, the EV can be the use of painkiller medication, mood, tiredness, or the subject's behaviors. The EV could affect the DV (LBP) [Figure 2].

CV

CVs are often referred to as nuisance variables.[2] The confounding occurs when EVs disrupt the observed relationship between an exposure and an outcome.[1,2,9,22,24]

- CV correlates with exposure
- CV poses a risk for the disease irrespective of the exposure
- CV does not form a direct part of the causal pathway between exposure and the disease. To clarify, a CV is linked to the predictor variable but may also contribute to the risk of the OV, necessitating its consideration. Confounding arises when the exposure is potentially influenced or distorted by EVs.

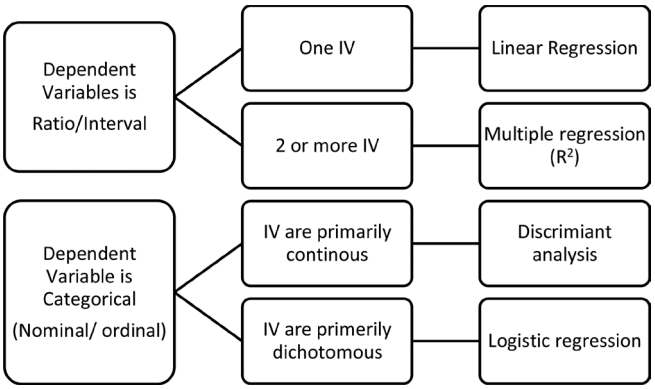

Figure 5: One or more independent variables predict one or more dependent variables.

For example, in a study evaluating the effectiveness of a certain exercise program for knee pain, the age of the participants could act as a CV. This is because age can independently affect knee pain and also influence the response to the exercise program. Therefore, the age of the participants needs to be controlled for or stratified in the analysis to ensure that its influence on the outcome is not mistaken for the effect of the exercise program.

Methods for CV control

- Propensity score matching: This technique involves creating a propensity score for each individual based on their

characteristics, including potential confounders. Individuals with similar propensity scores are then matched, balancing the distribution of confounders across exposure groups.[25]
- Inverse probability of treatment weighting (IPTW): IPTW assigns weights to individuals based on their propensity score, allowing for adjusting CVs in observational studies.[26]
- Directed acyclic graphs (DAGs): DAGs are visual representations of casual relationships that can help researchers identify potential CVs and plan appropriate statistical analyses.[27]
- Selection of statistical test on variables in relation to research question 1 [Figures 3a-c,4,5].

CONCLUSION

Healthcare professionals engaged in research must thoroughly comprehend variables, their types, and their roles. By incorporating this knowledge into their practice, professionals can improve patient care, advance healthcare knowledge, and develop evidence-based practices.

AUTHORS' CONTRIBUTIONS

AR and AKS designed this paper, provided the data material, interpreted the data, wrote the initial and final manuscript, and reviewed the literature. AR and AKS have critically reviewed and approved the final draft and are responsible for the manuscript's content and similarity index.

ETHICAL APPROVAL

The Institutional Review Board approval is not required.

DECLARATION OF PATIENT CONSENT

Patient's consent is not required as there are no patients in this study.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY FOR MANUSCRIPT PREPARATION

The author(s) confirms that there was no use of Artificial Intelligence (AI)-Assisted Technology for assisting in the writing or editing of the manuscript and no images were manipulated using the AI.

CONFLICTS OF INTEREST

There are no conflicting relationships or activities.

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