Review Article

Research Methodology in Periodontics - A Review

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ABSTRACT

The scope of research in any field can be enhanced by formulation of a research question with ample background and indication to be looked into as a subject of interest. As clinicians embarking upon research projects for academic progress, the most common issue encountered is the proper procedure to be followed to create a systematically constructed research proposal. This review elucidates on some key points and steps that should be followed in order to commence projects for discovery and/or recapitulate on scientific literature in the field of dental academia, and by extension, periodontics. The types of research that can be undertaken, drawbacks and pitfalls of every kind, as well as careful consideration to the primary and secondary objectives of every project have been explained. Additionally, a formulaic checklist is also given for researchers to follow to ensure complete writing of the report of each investigation, and which will help prevent any mistakes while conducting the research experiment in question.

Keywords: Biological Statistics, Clinical Research Protocol, Dissertation, Academic as Topic, Sampling Error, Sampling Bias.

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INTRODUCTION

Research, or careful re-investigation into any subject, process or concept is a fundamental tool in the effort to gain knowledge in said concept that has been previously unfounded. It is systematized, original and contributes to pre-existing information already available in literature. The word research is derived from the French *recherché*, from researcher, where *cherche* means to "look for" or "to search". It can be defined as search for new knowledge or as any systematic investigation with an open mind to establish novel facts, solve new or existing problems and prove new hypotheses, using a scientific method. Key actions that research involves are searching for, reviewing, and evaluating the knowledge collected thus far. Randomly selecting books from the library does not constitute research, nor does surfing the Internet. Conversely, what research does require, is a disciplined and organized approach, aided by inquisitiveness, creative capacity, time, and an open mind.

Background

Alexander III of Macedon, better known as Alexander the Great, is the creator of research done qualitatively. According to history, once his soldiers would conquer a new area, they would undertake a basic form of ethnography to teach the newly-conquered subjects into Grecian culture.[1] Fast forward to the late 1800s, there is evidence that some scholars were conducting ethnographic and one-on-one, in-person interviews. By the early 1900s, anthropologists had begun to gather first-hand data. From the 1930s to 1950s, there was a shift to the extensive use of quantitative research. More focus was given to the ability of ordinal and nominal categorization of the data collected. Even though qualitative research was considered "soft," focus groups were born, and by the 1960s there was a renewed interest in conducting qualitative research.

Both observational and analytical research has provided breakthroughs in the process of research, integrating classic and new techniques and information to create multiple streams of information that deliver knowledge that is aptly summarized along with a richer insight. When implemented suitably, research that yields new understandings may contribute to improving the quality of life and long-term scientific value.

Objectives of research methodology involved in periodontal health

1. To promote the gingival and periodontal health of the general public by improving education, service, practice and delivery of accepted practices
2. To contribute new knowledge or re-evaluate current knowledge to improve all phases of periodontal healthcare
3. To improve the techniques and practices of identifying, preventing and treating such diseases in at-risk individuals/groups
4. To understand not only the products of any scientific enquiry but also the process itself

5. To throw light on existing limitations and resources required to conduct a judicious research project.

TYPES OF RESEARCH

Research in periodontics is mainly defined as per several terms, that include—

Basic Research v/s Applied Research

- *Basic research* stems from a desire to increase knowledge and by curiosity
- It is intended towards answering questions pertaining to *why*, *what* and *how*
- While it increases understanding of fundamental principles, it may not necessarily result in an invention or solution to a practical problem.
- On the other hand, *applied research* is the term used for new information that is gained for a particular objective—be it academic or commercial, for example, research for a new non-abrasive dentifrice. It aims to solve practical problems at hand.

Empirical Research v/s Theoretical Research

- *Empirical research* is any research study where conclusions of the study are drawn from the evidence drawn as inference from observation rather than as per theory or logic.
- It involves phenomena that can be observed and measured, and entail both quantitative as well as qualitative studies.
- *Theoretical research*, or conceptual research, however, is generally restricted to abstract ideas or concepts. It usually doesn't involve any practical experiments, and is considered to be of lesser value than the other.

Qualitative Research v/s Quantitative Research [2]

- Both qualitative and quantitative research are, essentially, empirical forms of research.
- While *qualitative research* provides a subjective analysis, using non-statistical data that cannot be computed, it also employs an exploratory approach in research methodology.
- It answers *why* questions, and can be used to analyse, interpret and understand why certain phenomena occur.
- *Quantitative research*, on the contrary, uses the collected data and quantifies it using numbers to provide an objective analysis.
- It answers *how* or *how much* questions and can be used to test hypotheses to arrive at conclusive results.
- Qualitative and quantitative research also form an integral basis for levels of evidence required to postulate, prove and apply a new clinical or theoretical concept or approach in periodontics literature. [3–5]

WRITING A RESEARCH PROTOCOL— how to adapt for dissertations?

Scientific method is a set of standardized procedures carried out in sequence while conducting any research in order to ensure that the knowledge will be relevant, reliable and free of bias against any errors.

A standardized research protocol can be sectioned mainly into two—the problem which is to be investigated through research, and the method employed to investigate said problem. The former contains all statutory information about the project, such as

Title of the project, which is the most important while writing a protocol. Ideally it should be worded in an eye-catching fashion, and most importantly, must be brief and to-the-point.

The *research question*—it should be written in plain language to make the meaning self-explicable. It must show an understanding of the research phenomenon and must be accurately summarized. Any and all temptation to provide background should be avoided at this point in writing a protocol.

The *background of the study* that includes a review of all pre-existent literature on the concerned topic. The purpose of such a review is to reach at and draw attention to an existing gap of knowledge, if any. It is also prudent at this point to address deficiencies in studies done previously, thereby justifying undertaking the research project.

The *aims and objectives* should be stated explicitly, in order to have a clear idea about the intentions of the project. They should be achievable and measurable by acceptable scales and units of measurement. Additionally, they should also be confined to the intention of the project and not deviate to include, say, "the bigger picture."

The writing of a research protocol requires meticulous attention to detail and careful execution of each of the following steps:

1. Problem formulation

The ideal requirements to formulating a research problem or research question are—

- It must be significant to some aspect of periodontal healthcare
- If solved, it should contribute to delivery of optimal delivery of gingival and periodontal health by leading to new knowledge, re-affirming or improving current practices or developing new theories
- The problem must be able to be observed and capable to be measured through known and accepted methods of quantification
- The research problem should be of interest to the researcher as well as to the reader, who must be capable of accessing the necessary resources for

proper investigations, adhering to the scientific method.

2. Hypothesis formulation

A hypothesis refers to a statement about a phenomenon in the population of interest on which research is conducted. It could be generated by deductive/inductive reasoning, and when tested, should lead to the identification of the most likely causes of periodontal/gingival disease.

It is a tentative prediction or explanation of the relationship between two or more variables. A well-constructed working hypothesis should reflect the depth of knowledge on the researcher's part and must simultaneously identify all relevant variables.

3. Sampling and sample designs

Sampling is the process or method of choosing a part of the reference or parent population, one that fits appropriate characteristics, considering any and all inclusion and exclusion criteria, of adequate size. The part thus selected is called a *sample*. Advantages of selecting a sample rather than involve the entire population are that doing so reduces the cost of conducting the investigations, lessens the time required and the number of experienced personnel needed. Sampling also allows a more exhaustive examination of the units of observation and helps to provide meticulous coverage of the sample units.

There are primarily two kinds of sampling: purposive or random. *Purposive selection* is easier and requires next to no preparation of the sampling frame. On the other hand, it inevitably leads to an under-representation of the rates of occurrence of the phenomenon being investigated. *Random selection*, on the contrary, ensures that all variables have an equal chance to appear in the sample, showing no prejudice.

Commonly the sample designs we use in periodontics are—

- Simple random sampling: this method of selecting a sample ensures that every unit in the reference population is given equal opportunity to be incorporated in the final subset. The selection of each proband is determined purely by chance. The basic sequence of selection is—
  - Prepare sampling frame
  - Decide the total sample size
  - Selection of the required number of probands

In order to ensure unpredictability and randomness, in common practice, either of the following methods may be employed:

i) *Lottery method:* A highly popular method, in which the sample units are allotted a number on separate paper slips, bearing the same shape and size. These paper slips are then selected at random by the probands wearing blindfolds, prior to which they are shuffled. This method remains one of the easiest in sample selection, but it becomes cumbersome when the reference population grows large, thereby limiting its use.

ii) *Table of random numbers:* this method can claim to assure randomness and elimination of personal bias to a greater extent. The process consists of a random arrangement of digits from 0 to 9 in rows and columns, arranged in a manner such that purposive selection is prevented. The selection of digits is done in either a vertical or horizontal direction. However, this method is again cumbersome due to its requirement to catalogue the probands of the entire sample population, which may lead to enhanced time and cost to collect the data.

- Systematic sampling: this method of sampling obtains samples by selecting one unit randomly, which is then followed by selection of additional units at intervals that are spaced evenly, until the required sample size has been achieved. For example, to obtain a sample of the patients undergoing non-surgical periodontal therapy in a clinic in a week, assuming that there are 150 patients at the clinic, and the sample size required for study purposes is supposedly, 10, then the quotient is 150/10= 15. The first patient number from the population is selected at random, say patient number 3. The next unit will be 3+15= 18. Hence, serially, the sequence of the sample units will be of the serial numbers 3, 18, 33, 48, and so on until the sample size of 10 units have been obtained.

This method can be employed until there exists some periodic repetition of any event in the population.

- Stratified sampling: in this technique of sampling, the reference population is subdivided into groups/strata as per common attributes required. This can be achieved by either of the following mechanisms—

  i) Stratified random sampling:

     a. The sample population is divided into sub-groups known as *strata*, in a way that each stratum is homogenous in characteristic.

     b. A simple random sample is then chosen from each subgroup.

  ii) Stratified systematic sampling: the method consists of subdividing into strata, followed by systematic selection of sample units as explained previously.

Stratification of sample units should be used when the reference population exhibits heterogeneity in its composition in relation to the characteristic the researcher aims to study. It ensures the samples thus selected are more representative, accurate and concentrated over a wider area, geographically. Systematic selection also aids in removal of sampling variation. The only comprehensible limitation of this technique could be attributed to the

difficulty one might face while delineating the divisions for each stratum precisely, such that each group is homogenous in characteristic.

- Cluster sampling: this method is employed in use when the population by itself, falls into natural groups or "clusters" of probands, such as villages, schools, communities, wards, etc. Herein, a sample is selected by simple random sampling, but instead of individual probands, groups or clusters of individuals are selected. The sample units are these clusters, and the sampling frame or reference population consists of a collection of several clusters.

This method of sampling is much simple to enact, from an administrative point of view, aside from being much more economical compared to traditional sampling at random. The only downside to this method is that should any cluster were to be composed of individuals who are characteristically similar, then the results obtained would not be eligible for generalization onto the entire sampling frame.

Aside from the aforementioned, there are also other methods of selecting a sample used regularly in research methodology in periodontics, and dentistry in general, which include—

- Multiphase sampling; and
- Multistage sampling

These are sampling methods which use information collected in parts from both the whole sample population as well as from sub-sample groups. The collection of data is achieved in sequential stages, or phases, as understood by the names. Survey by such technique is more economical, less stressful, and easier to enact.

The selection of a sample size of appropriate size directly influences the precision of estimates gathered from the study. An optimal sample size should be based on an approximate idea of estimate of characteristics under study and its variability from unit to unit in the population. While selecting the sample, the researcher should have adequate knowledge about the characteristic under study and also the probability level within which desired precision is to be maintained. Other factors which influence the success of sampling, designing of sample and reference population and sample size estimation include the availability of experimental material, resources and other practical considerations.

The size of the sample is calculated using the formula $n = 4pq/ L^2$, where sample size is denoted by n, p implies the approximate prevalence rate of disease, q is the statistical prevalence subtracted from unity i.e., $1-p$, and the permissible error in the estimation of p is denoted by L. [6]

While sampling may be quite a useful tool in order to select the population for a study, it also introduces its fair share of disadvantages in the form of *errors*. These could be attributed to both faults in sampling method, inadequate sample size or faulty sample design, or to non-sampling, i.e., external factors, such as—coverage failure, bias, errors while processing the statistics.

4. Collection of data

As mentioned previously in this review, depending on the nature of variables, data is classified as either qualitative or quantitative. Quantitative data can be further broken down on the basis of nature of variables governing the data as either *discrete* or *continuous*. Discrete variables are essentially quantitative values which can only be expressed in integer values, while phenomena which can take on different values even to a decimal point are called continuous variables.

Variables can also be differentiated based on significance. For example, if one variable is the result of another variable, it is termed as a *dependent variable*, and the antecedent variable would be the *independent variable*. For instance, if we say that amount of plaque formation in the mouth depends on the amount of saliva, then the amount of plaque becomes the independent variable and the saliva content becomes the dependent variable.

In the event that an independent variable that is not related to the purpose of the study affects the dependent variable, it its termed as being an *extraneous* or *confounding variable*. Any and all effect these extraneous variables have onto the dependent variable or the study itself has been described technically as an *experimental error*.

Considering all these, a study must therefore, ideally be so designed that the effect upon the dependent variables is attributed entirely to the independent variable and not to some extraneous variables (errors).

Collection of data in periodontics research can be executed via either a *primary source* or a *secondary* one. While the former entails information that is received first-hand, the latter makes use of second-hand information, or data that has already been pre-recorded such as past dental records, pending analysis. Primary sources of data could be via personal face-to-face interviews, which hold the most value in terms of accuracy, via oral health examinations or by using a questionnaire, which could either be mailed to the subjects or filled in personally at site.

5. Presentation of data

The data collected via correct use of sampling design and data collection methods, at this point, requires to be presented to the reader in a suitable fashion. The presentation should be simple, legible and concise to the investigator and the reader alike. In periodontics, this is achieved by mainly two types—*tables* and *charts*. [7]

Tables can either be a *master table*—one which contains and delivers all the pertinent data at a single glance to the reader, a *simple table* which alludes to only a single characteristic and its relationship with the subjects, or a *frequency distribution table*, that which quantitates the

repetitiveness of a certain characteristic or trait, allowing the investigator to draw conclusive inferences.

Charts, on the other hand, are diagrammatic expressions of the data collected and the inter-relationships between the subsets therein. They aim to provide the reader with a "bird's eye view" of the data, and work as an excellent visual aid while conducting a study. All charts, and by extension, diagrammatic representations of data are based on drawing relationships against the frequency of each characteristic that is under investigation. These representations can be either bar charts, which plot the frequency on longitudinal bars, or pie charts, which conglomerate all the data around a circle, or "pie" with a total angle of 360^{o}, with each subset represented by a fraction of the total angle, or "slices" of the pie. These two forms of representing collected data are the most popular, in terms of use in scientific literature, as well as in education and delivery of data to the layman.

Apart from these, other forms of presentation of data available in periodontics research include—*line diagrams*, *histograms*, *frequency polygons*, *cartograms*, *pictograms* and *scatter diagrams*, all of which are used extensively for a similar purpose.

6. Analysis and interpretation

This is the process by which the data obtained via research is clarified, so that an inference can be drawn. [8] The emergent knowledge that comes forth from this *is finally applied to solve the research question*. Analysing the data helps to extricate the useful information from the pool of irrelevant ones that have been gathered while conducting the study, thereby acting as a tool for the investigators to make and draw well-informed conclusions.

A major component of analysis of the results of a study includes the use of biostatistics. The bases for such an analysis are denoted by *U* i.e., the population under study, *V* i.e., the variable(s) influencing the outcome, and *P* i.e., the distribution of probability of each event occurring in the study population in the relevant timeframe. The benefits of putting the data collected through algorithms to draw inferences include—

a. To test whether difference between 2 populations is real or a chance occurrence;

b. Study the correlation between attributes in same population;

c. Evaluate the efficacy of vaccines, serum etc.;

d. Measure morbidity and mortality;

e. Evaluate achievements of public health programs; and

f. Help promote legislation and create administrative standards for oral health.

Periodontics, and any research thereof, majorly employs certain techniques to achieve correct analysis and judicial interpretation, which include calculation of statistical averages, measures of dispersion and tests of significance.

At this point, it is imperative to note that tests of significance are instrumental in determining which variable is influential on the interrelationships between the subject and the study. They help to determine the statistical significance, which is commonly agreed to be at $p\ value \leq 0.05$, i.e., there is a less than 5% probability that the null hypothesis is valid, meaning that the result of the analysis can be interpreted as being a result of the interactions between the variables of the study, and not due to chance. Such a result is deemed to be *statistically significant*. [9]

However, statistical significance of the result of analysis does not necessarily infer upon it the evidence of causation, meaning that it does not always translate clinically, in the practical scenario. This is important as it draws direct attention to the clinical value of the results obtained. Simply put, the existence of the effect of variables in a study determines its statistical significance, whereas the impact of the said effect becomes its practical significance.[10] In a lot of cases, no statistical test can tell the investigator whether the effect is large enough to be important in the field of study.

7. Writing the report

Finally, once all the aspects of conducting a fair and comprehensible research study are dealt with, comes the preparation of a report. This report should be a comprehensive and exhaustive document which aims to familiarize, outline and conclude on the methodology of the study done in its entirety, any pitfalls if encountered, and inferences that may be drawn successfully. A report should be written sequentially as follows:

1. General information

2. Contents

   i) Title page

   ii) Table of contents

   iii) CHAPTER I – Introduction

   - Statement of the problem
   - Purpose
   - Significance of the study
   - Hypotheses

   iv) CHAPTER II – Background

   - Review of literature
   - Operational definitions

   v) CHAPTER III – Methodology

   - Complete outline of research plan
   - Validity & Reliability—addressing the questions

   vi) CHAPTER IV – Results

- Analysis and interpretations

vii) CHAPTER V – Conclusions & recommendations

3. Appendix

- Citing references
- Bibliography
- Secondary referencing
- Citation & reference styles – Harvard, Vancouver, etc.

CONCLUSION

Research is an indispensable aspect of clinical study. It is an important cog in the wheel towards gaining and establishing newfound knowledge about any new concept, whether hypothetical or in practical use. However, it requires tedious determination, meticulous attention to detail, and an expansive knowledge of every feature of the methodology behind research, in order to ensure that the investigator does not deviate from the main purpose behind conducting each investigation. Only with a thorough appraisal and implementation of all the aspects of basic research methodology in periodontics, can we hope to achieve fruitful results in current and future practice, which will show promise in supplanting as well as bolstering the current clinical concepts in periodontics research.

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