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MixedMethods Research in Public Health: Theoretical Foundations and Practical Applications

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Abstract
Contemporary public health issues are often complex, multifaceted, and deeply embedded in social contexts. These challenges necessitate research approaches capable of providing both breadth and depth of understanding. Mixed methods research (MMR), which combines qualitative and quantitative methodologies, offers a comprehensive strategy for addressing these complexities. MMR enables researchers to build on the strengths of both paradigms, thereby producing findings that are more robust, nuanced, and grounded in diverse forms of evidence. Despite its increasing use in public health particularly in low- and middle-income countries -many researchers lack a clear understanding of MMR's theoretical foundations and practical implementation. This article provides an in-depth review of the philosophical roots, methodological debates, research designs, sampling strategies, integration techniques, and analytical considerations associated with MMR. It also highlights the conditions under which MMR is most appropriate, outlines its key benefits and limitations, and illustrates its application in public health contexts. The goal is to support researchers and practitioners in using MMR effectively to investigate and address complex health issues.

Keywords: Mixed Methods Research, Public Health, Research Design, Methodological Integration, Research Philosophy

History of Methodological Debates in Public Health
Public health has traditionally followed a positivist paradigm, largely influenced by one of its core quantitative disciplines: epidemiology[1]. The positivist approach posits that societies, like the physical world, operate according to universal laws such as Newton's Law of Gravity and that valid knowledge is derived from data confirmed through sensory experience and empirical evidence[2]. This quantitative orientation has enabled public health to define health issues (what), measure the magnitude of health-related problems based on person, place, and time (who, where, and when), and examine their causes (how and why). However, toward the end of the 20th century, the emergence of social medicine prompted a paradigm shift, leading to the development of social epidemiology[3,4]. This shift recognized the need for approaches that could better capture the complexity of social phenomena related to human behavior.

To address these complexities, non-positivist methodologies particularly qualitative methods were developed. These approaches gained traction as valid tools for understanding "social truths" as they naturally occur. Qualitative methods aim to develop deep, contextual understandings of social phenomena[5].

Today, quantitative and qualitative methods are frequently combined[5]. This integration, however, has raised methodological questions for researchers[5,6]. It may seem paradoxical to combine methods rooted in different philosophical traditions qualitative (inductive) and quantitative (deductive) to draw valid inferences. Given the complexity of truth, no single approach can fully explain it. A dialectical perspective, foundational to ancient Indian philosophies and echoed in Western traditions by thinkers such as Marx, Engels, and Hegel, offers a resolution. This philosophy

emphasizes interaction and contradiction as drivers of transformation, making it a useful framework for integrating qualitative and quantitative methods[7,8].

The Rise of Mixed Methods Research in Public Health

Quantitative research dominated public health for much of its history. In recent decades, however, qualitative approaches have gained recognition, and by the late 20th century, the use of mixed methods became widely accepted in the social sciences[9]. Yet in public health, the use of mixed methods has been relatively limited [10–14]. Often, the integration of qualitative and quantitative data has been partial, used mainly for triangulation purposes [15]. More recently, there has been broad recognition that mixed methods research (MMR) offers a powerful approach to addressing complex questions and is essential for generating, refining, and advancing new ideas in public health [16].

Debates continue in the social sciences about whether and how quantitative and qualitative methods should be combined. Some argue that the philosophical foundations of these approaches are too distinct to allow effective integration. Others acknowledge these epistemological differences but believe that combining the two types of evidence can yield valuable insights. In response, scholars have proposed various frameworks for capitalizing on the strengths of both approaches [17–19].

Rather than focusing on whether one method is superior, the goal of this seminar is to explore how to conduct research that effectively addresses questions requiring a combination of methods. In today's complex world where policy decisions influence the health of entire populations both quantitative and qualitative methods are sometimes necessary to gain a comprehensive understanding of public health challenges.

Methodological Approaches in Research

Research can be approached using one of three methodological frameworks:

- **Mono-methodological approach:** Involves the use of a single method, either quantitative or qualitative.
- **Multi-method approach:** Uses multiple methods from the same paradigm (e.g., two or more quantitative or qualitative methods).
- **Mixed-methods approach:** Integrates both quantitative and qualitative methods within a single study [0–23].

This article focuses on the third approach: **mixed methods research.**

Definition of Mixed Methods Research (MMR)

There are numerous definitions of MMR-Johnson's review identified more than nineteen[17]. Alternative terms include integrative research, blended research, multiple methods, triangulated studies, and mixed research. The term mixed research is favored for its neutrality and inclusiveness. Johnson defines MMR as: "A type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., data collection, analysis, and inference) for the purposes of broadening and deepening understanding and corroboration."

MMR vs. Multiple Methods Research

The terms mixed methods research and multiple methods research are often used interchangeably, but they are not synonymous. The key difference lies in the purpose of data integration. MMR involves the integration of qualitative and quantitative data to answer a single research question. In contrast, multiple methods research uses qualitative and quantitative data to answer separate questions within the same study.

Philosophically, MMR is rooted in pragmatism, while multiple methods research may be grounded in either positivist or non-positivist traditions[25,26].

Philosophical Foundations of MMR

Which philosophical stance best supports MMR? Traditionally, constructivism is associated with qualitative research, and post-positivism with quantitative research. Pragmatism, however, serves as the foundation for MMR, allowing the research problem not the method to guide the choice of tools and approaches.

Today, pragmatism is the dominant philosophy underpinning MMR. Mixed methods researchers often adopt philosophical orientations that blend post-positivist and constructivist views, pragmatism, and transformative worldviews [17–19]. While conflicting philosophical positions can create tensions, MMR also offers the opportunity to transform these tensions into deeper insights through dialectical inquiry[27].

A pragmatic perspective emphasizes doing "what works," using multiple methods, focusing on the research problem, and valuing both subjective and objective knowledge[28]. A transformative perspective provides a guiding framework rooted in the pursuit of equity and justice, shaping the entire research process—from problem identification to dissemination of findings [29].

Core Assumptions and Benefits of MMR

MMR brings several advantages, as outlined by various scholars [17–19, 27–29]:

- **Triangulation:** Seeks convergence or corroboration of findings across methods.

- **Complementarity:** Uses one method to elaborate or clarify the results of the other.
- **Development:** Uses findings from one method to inform the design or interpretation of the other.
- **Initiation:** Identifies contradictions or new perspectives that reshape the research question.
- **Expansion:** Broadens the scope of inquiry by using different methods for different aspects of the study.

Models for Mixed Methods Research (MMR)

Models for conducting MMR can be classified based on various parameters. Several mixed-technique designs exist, and researchers may select an appropriate model depending on the research topic. The following list is not exhaustive but represents common methodologies employed in health science research[5,30–33].

Major MMR Designs Based on Timing

MMR designs based on the timing of qualitative and quantitative data collection and integration are generally categorized into five types:

- **Concurrent (Parallel or Convergent) Design**

In this design, qualitative and quantitative data are collected simultaneously but independently. The datasets complement each other and are merged during analysis. For example, a researcher may collect qualitative interview data on participants' experiences with a health promotion program alongside quantitative survey data measuring program outcome. The integrated analysis compares and synthesizes findings from both datasets to address the study objectives.

- **Sequential Design**

This design involves collecting and analyzing data from one method first, with the results informing the subsequent method. It includes two main types:

1. Exploratory sequential: Qualitative data collection and analysis occur first, followed by quantitative methods designed based on qualitative findings.
2. Explanatory sequential: Quantitative data are collected first, followed by qualitative data aimed at explaining or elaborating on quantitative results. For example, qualitative interviews may be conducted to explore the reasons behind observed quantitative trends.

- **Transformative Design**

This design can be concurrent or sequential but is explicitly guided by a theoretical framework or lens (e.g., gender theory, critical race theory) with the aim of addressing social justice or equity issues.

- **Nested (Embedded) Design**

In this approach, one method is embedded within the other to provide supplementary insights. For instance, in an experimental study, qualitative data might be collected alongside quantitative measures to explore participants' experiences of the intervention. The embedded design can be sequential or concurrent and enriches understanding by combining complementary data types.

- **Multiphase Design**

This design consists of a series of related studies conducted over time, connected by a common goal. Multiphase designs often incorporate both concurrent and sequential elements. For example, multiple projects (qualitative, quantitative, and mixed methods) may be conducted sequentially to develop, implement, and evaluate a health promotion program.

Major MMR Designs Based on Weight

MMR designs can also be classified according to the relative emphasis or "weight" given to qualitative and quantitative methods:

- **Qualitative Dominant MMR**

Here, qualitative methods predominate but are supplemented by quantitative data. This design suits researchers primarily focused on qualitative inquiry who recognize the added value of quantitative data.

- **Quantitative Dominant MMR**

Quantitative methods predominate but are supplemented by qualitative data. This design is ideal for researchers primarily conducting quantitative studies who see benefit in integrating qualitative insights.

- **Equal Status MMR**

In this design, qualitative and quantitative methods carry equal weight. This balanced approach is often considered the ideal or "pure" form of MMR.

Balancing Methods in MMR

While using multiple methods to gather data can be advantageous, it is not always feasible or appropriate. Researchers should carefully consider the balance between methods based on the research questions, available resources (e.g., funding, expertise), and the value each data type brings to the inquiry. The data collected should remain manageable and meaningful. There is no fixed formula for balancing methods; rather, it depends on the specific context of the study [19,30,34].

Is MMR Always Better?
Not necessarily. The appropriateness of MMR depends on the research objectives and the extent to which integrating methods enhances data quality. The addition of a secondary method should thoughtfully address gaps left by the primary approach rather than being added indiscriminately[19,34].

Sampling Methods and Sample Size in MMR
Sampling strategy and sample size are critical considerations in MMR and should align with the research question and design. Approximately 24 sampling strategies exist for MMR, including six probabilistic and 18 non-probabilistic schemes [35]. Typically, qualitative research relies on non-probability sampling, while quantitative research favors probability sampling.

Sample size in quantitative research is determined statistically to represent the population adequately, accounting for variability and hypothesis testing. In qualitative research, sample size is determined by data saturation the point at which no new information emerges, such as during focus groups or in-depth interviews.
For MMR, the sample size is generally the minimum required for both qualitative and quantitative components [35]. A recent review provides detailed criteria for MMR sample sizes[36].

A tentative typology of mixed method sampling includes concurrent, basic, multilevel, sequential, and multiple sampling strategies. For example, purposive sampling can stratify participants into groups (e.g., above average, average, below average) for in-depth qualitative study within each stratum. Sequential sampling involves one phase (qualitative or quantitative) informing the subsequent phase. Concurrent sampling selects samples independently for each method. Multilevel sampling may combine random sampling at one level (e.g., districts) and probability sampling at another (e.g., health facilities) [37, 38].

Data Combining Methods in MMR
Three primary approaches to integrating data are commonly described[33,39]:

- **Merging Data**

Qualitative data (e.g., texts, images) and quantitative data (numerical) are combined during analysis and interpretation. This can involve reporting quantitative findings followed by qualitative themes that support or challenge them, or presenting both data types together in tables or figures.

- **Connecting Data**

Analysis of one dataset informs the collection of the other. For example, quantitative survey results may guide the development of qualitative interview questions or participant selection.

- **Embedding Data**

A secondary dataset is nested within a primary design. For instance, qualitative data collected during or after a quantitative intervention trial to enhance understanding of participant experiences.

Why Mixed Methods Research? Strengths of MMR
There are several reasons to conduct mixed-methods research[5,30–32]. Typically, research employs multiple data collection methods to enhance the validity and reliability of findings. Since all methods have inherent strengths and limitations, combining methods allows for triangulation and validation that help overcome the weaknesses specific to any single approach.

MMR also helps reduce biases such as interviewer bias, instrument error, and interpretation bias. By integrating multiple theories, observers, methods, and data sources, researchers can address issues associated with single-method, single-observer, or single-theory studies.

Qualitative data such as narratives and images add depth and meaning to quantitative data, while quantitative data provide precision and generalizability to qualitative insights. This synergy enables MMR to address a wide range of research questions. Corroboration and convergence of findings strengthen evidence, revealing insights that might be lost using only one method.

Limitations of MMR
Despite its advantages, MMR poses methodological challenges that must be anticipated[30,39,40]:

- **Resources:** Collecting and analyzing diverse data types demands significant time and resources, including multiple phases of data collection and analysis.
- **Teamwork:** Interdisciplinary or multidisciplinary collaborations may involve diverse methods and writing styles. Leaders must manage the challenges and rewards of such teamwork effectively.
- **Word and page limits:** Scientific journals often impose strict word or page limits, requiring creative presentation of MMR approaches, such as tables or figures summarizing methods and designs.
- **Sampling issues:** Selecting appropriate samples for both qualitative and quantitative components can be complex (discussed earlier).

- **Analytic and interpretive issues:** Data integration may yield conflicting or inconsistent findings, especially in parallel designs. Resolving discrepancies might require additional data collection or revisiting datasets. In sequential designs, deciding which findings from one phase warrant follow-up can be difficult. Unequal attention or differing validity of datasets, as well as incompatible underlying philosophies, can complicate interpretation.

- **Practical Applications of MMR in Public Health**

MAXQDA 2020 software is widely used for analyzing quantitative, qualitative, and mixed-methods data, particularly for data integration. It supports linking qualitative and quantitative data, analyzing variable values and code frequencies, and creating joint displays such as crosstabs, quote matrices, and document maps.

Analysis of Qualitative Data	Analysis of Quantitative Data
Data import: texts, PDFs, tables, videos, webpages, social media, etc.	Descriptive statistics: frequency tables
Data exploration: word searches, memos, comments, paraphrasing	Charts: bar charts, boxplots, histograms
Data analysis: coding, memoing, summaries, visual tools	Crosstabs and correlation analysis
Reporting: visual tools, data exports	Inferential statistics: ANOVA, chi-square tests, correlations

Table 1: summarizes some common qualitative and quantitative data analysis methods used in mixed methods studies

Methods of Integrating Quantitative and Qualitative Data

Three main types of data integration in MMR are:

- **Sequence-based Integration**

Occurs in sequential designs where results from one phase guide data collection or instrument development in the next (e.g., selecting cases or designing interview guides).

- **Data-based Integration**

Involves combining quantitative and qualitative data for at least some study cases.

- **Results-based Integration**

Combines findings from qualitative and quantitative analyses, typically in the discussion or interpretation phase. This is the most commonly used integration method in public health research.

Conclusions

Public health research addresses complex societal issues, ranging from policy development to intervention delivery. Mixed methods research enhances understanding by rigorously integrating quantitative and qualitative approaches to produce robust, realistic findings.

MMR leverages the strengths of both methodologies, providing more comprehensive evidence to address multifaceted public health challenges. Therefore, public health researchers should develop competence in MMR, including its definitions, philosophical foundations, designs, sampling strategies, data analysis, and interpretation.
While MMR has limitations, like any methodology, it equips researchers with stronger evidence for solving public health problems. Results-based integration or triangulation remains the most frequent and effective method of combining mixed methods findings in public health.

Authors' Contributions

AY conceptualized the study, ensured data curation, conducted formal analysis, and wrote the manuscript.

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Ethics Approval and Consent to Participate

Not applicable.

Availability of Data and Materials

All data generated or analyzed during this study are included in this published article.

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Consent for Publication

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