

Conceptualizing Longitudinal Mixed Methods Designs: A Methodological Review of Health Sciences Research

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Abstract

Longitudinal research is well suited for investigating phenomena that change over time. With the growing acceptance of mixed methods, researchers are combining qualitative and quantitative approaches within longitudinal research. However, little attention has been paid to how researchers integrate longitudinal mixed methods databases. The purpose of this methodological review was to describe how researchers combine mixed methods and longitudinal approaches in practice and delineate dimensions and issues inherent within these complex designs. We examined published empirical studies from the health sciences that self-identified as longitudinal and mixed methods. Our results identify major dimensions, variations, and issues for designing longitudinal mixed methods research and suggest recommendations for researchers interested in using this complex approach.

Keywords

mixed methods designs, longitudinal research, repeated measures, procedural issues, health sciences

Researchers in the educational, social, and health sciences are using increasingly complex mixed methods designs. The longitudinal mixed methods design, in which researchers combine qualitative and quantitative approaches with longitudinal research, is an example of one such complex approach identified in the literature (Plano Clark, 2010). While longitudinal approaches are well suited for investigating phenomena that change over time such as developmental processes, responses to interventions, and societal trends, they present many challenges. Notably, the authors of this article are increasingly engaged with the methodological issues associated with longitudinal mixed methods approaches as experienced within our own research

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and methodological writings (e.g., Plano Clark et al., 2013; Schumacher, Plano Clark, Hertzog, & Lydiatt, 2012). Although much is written about mixed methods research (e.g., Tashakkori & Teddlie, 2010), to date the mixed methods literature has focused on cross-sectional approaches. Little attention has been paid to longitudinal approaches for mixed methods (Van Ness, Fried, & Gill, 2011).

In a methodological discussion focused on the process of interpretation within a longitudinal mixed methods study on aging, Van Ness et al. (2011) suggested three models for conducting longitudinal mixed methods studies in clinical biomedical research:

1. *Prospective*: Qualitative data collected once at the first time point of the quantitative longitudinal strand to examine participants' expectations about the issue to be measured quantitatively
2. *Retrospective*: Qualitative data collected once at the last time point of the quantitative longitudinal strand to examine participants' recollections of the issue that was measured quantitatively
3. *Fully longitudinal*: Qualitative and quantitative data collected at all time points.

Van Ness et al. (2011) noted that the fully longitudinal model is potentially costly, could overburden participants, and may introduce bias into statistical results if the qualitative data collection influences responses to the repeated quantitative measures. They cautioned that longitudinal designs should be chosen with care because they are inherently more complicated, particularly as related to the fully longitudinal design. Van Ness et al. noted that the three models are "logical possibilities" (p. 299) drawn from the quantitatively oriented field of clinical biomedical research, and therefore they may not reflect the approaches being used. Presently, little is known about longitudinal mixed methods designs, including how they are used in practice and the issues that emerge when researchers implement these complex designs.

Methodological reviews in the area of mixed methods research have been useful for examining the prevalence, designs, procedures, issues, and value associated with mixed methods research (e.g., Ivankova & Kawamura, 2010; Molina-Azorin, 2011; Plano Clark, 2010; Ross & Onwuegbuzie, 2012; Stentz, Plano Clark, & Matkin, 2012). This strategy for studying mixed methods research can provide valuable insights for both methodologists and applied researchers because it provides a means to learn about the practices used in empirical research studies that were implemented and published. Because so little is known about longitudinal mixed methods approaches, we decided to conduct a methodological review to describe current practices associated with the use of longitudinal mixed methods research approaches as reported in published empirical research. Our research questions were the following:

- What are the different ways that longitudinal mixed methods research designs are used?
- What issues occur during the conduct of longitudinal mixed methods research?

Conceptual Framework

Three conceptual perspectives guided this methodological review: a definition of mixed methods research, a definition of longitudinal research, and a research design framework.

Mixed Methods Research

Mixed methods research is a methodology that encompasses the full process of research including philosophical assumptions; research questions; design; methods of data collection, analysis,

and integration; and reporting structures (Creswell & Plano Clark, 2011; Greene, 2007; Tashakkori & Teddlie, 2010; Teddlie & Tashakkori, 2009). To facilitate the identification and analysis of published articles, we used a methods-focused definition for mixed methods research. That is, we defined mixed methods research as research that involves collecting, analyzing, and integrating quantitative data and qualitative data within a single study or multiple phases of a program of research (Creswell & Plano Clark, 2011). The integration of quantitative and qualitative data may take many forms including connecting results from one data set to the collection of data from another; juxtaposing quantitative and qualitative results for comparison; transforming one form of data to facilitate the other form of analysis; or forming interpretations from the two sets of results (Creswell & Plano Clark, 2011; Teddlie & Tashakkori, 2009).

Longitudinal Research

Longitudinal research is a research approach in which the researcher repeatedly collects and analyzes data over time. We used Van Ness et al.'s (2011) definition of longitudinal research as research that involves the repeated collection of at least one data source at three or more points in time. That is, this investigation excluded studies when data were collected at two time points, such as a pre- and posttest. Analysis of data collected at multiple time points may involve interpreting qualitative patterns (Saldaña, 2003), visual graphical analysis techniques (Brown, McGuire, Beck, Peterson, & Mooney, 2007), and/or statistical approaches for repeated measures such as repeated measures analysis of variance and latent growth curve analysis (Long, 2012).

Research Designs

Research designs are sets of procedures for collecting, analyzing, interpreting, and reporting data that logically fit together to address a research purpose (Creswell, 2012). In mixed methods, research designs serve as conceptual frameworks for organizing, conducting, and communicating the qualitative and quantitative data collection and analysis and the integration of the two strands (Creswell & Plano Clark, 2011; Teddlie & Tashakkori, 2006). Although scholars have critiqued the utility of mixed methods design classifications (e.g., Bazeley, 2010; Guest, 2013; Maxwell & Loomis, 2003), design typologies have received extensive attention in the field from its earliest writings (e.g., Greene, Caracelli, & Graham, 1989); are used extensively in reports of mixed methods research today; and provide prototypical models that are useful for researchers learning about mixed methods and weighing different approaches as they design their mixed methods studies.

Scholars generally emphasize a small number of dimensions to describe mixed methods designs. While differing opinions abound as to which dimensions are most salient (Guest, 2013), there are several points of general agreement including the dimensions of timing and integration (Creswell & Plano Clark, 2011; Greene, 2007; Teddlie & Tashakkori, 2009). *Timing* (e.g., concurrent or sequential) refers to when the quantitative and qualitative methods are used relative to each other to address a study's research questions. The dimensions of *integration* include the point of interface (where in the research process the two methods interact with each other; Morse & Neihaus, 2009) as well as the integration strategies (e.g., merging two databases during analysis or connecting from one type of results to the other type of data collection).

While acknowledging the limitations inherent in any typology of research designs, this investigation also applied the concept of designs as a framework useful for describing

researchers' applications of longitudinal mixed methods approaches and the dimensions that differentiate these approaches. We viewed research designs both as prototypical models that may be described in typologies and also as the unique methodological product that results from researchers' design process in the context of their specific study context (Crotty, 1998). Our aim was to describe the different ways that researchers applied longitudinal mixed methods approaches in the unique contexts of their studies and to identify dimensions useful for representing differences among the approaches. We started with Van Ness et al.'s (2011) prospective, retrospective, and fully longitudinal models as an initial framework for describing the longitudinal mixed methods approaches that researchers used in their studies. As summarized in the previous section, the Van Ness et al. models differ in terms of the purpose for the collection of qualitative data and its correspondence with the collection of quantitative repeated measures (i.e., at the first, last, or every time point).

Method

We conducted a systematic methodological review, which is a rigorous study of the methods and procedures utilized within published research (Khan, Kunz, Kleijnen, & Antes, 2003), to address our purpose. We chose to search PubMed (<http://www.ncbi.nlm.nih.gov/pubmed/>), a free online database that is a service of the U.S. National Library of Medicine and contains access to more than 23 million citations for biomedical literature. This database was selected because of its extensiveness, the health science background and prior experiences of several members of the team, and the apparent availability of articles that indicated the use of longitudinal mixed methods approaches found during preliminary exploratory searches. Although PubMed has a health science focus, that focus is broadly defined and the database includes research from many disciplines including psychology and education.

We designed our search to identify completed empirical studies that authors had themselves conceptualized as mixed methods and longitudinal. We wanted to review examples where the researchers were likely to have *integrated* the quantitative and qualitative components, and therefore we searched for the term "mixed methods" and required that it appear with the terms (longitudinal OR "repeated measures") in the title and/or the abstract of the article. We purposefully limited the search to the presence of these terms in titles/abstracts to identify information-rich sources for learning about the practices and issues associated with this approach by locating articles that the authors had explicitly specified as using longitudinal mixed methods designs. We included all articles that were published through the end of 2012, including those published electronically ahead of print. A total of 94 articles met these search criteria.

We completed two rounds of review of the 94 hits to identify the sample of published longitudinal mixed methods studies for our analysis. First, two researchers (NA and YZ) reviewed all the titles and abstracts. They recorded quotations that indicated the use of the search terms, noted whether the articles reported results of empirical studies, and determined whether they met the research team's definitions of mixed methods research (i.e., combining quantitative and qualitative strands) and longitudinal research (i.e., collecting one source of data at three or more time points). Based on this review, 67 articles were identified for a full-text review. The second round of reviews proceeded similarly with two authors (VPC and NA) reviewing the full text of the 67 articles. During the two rounds of review, articles were removed from the database only if there was clear indication that (a) they were not empirical research reports ($n = 14$), (b) they were study protocols without reported results ($n = 8$), (c) they were studies that did not meet our definition of mixed methods or longitudinal methods ($n = 38$), or (d) they used the search terms in ways other than to refer to the methods of the reported study ($n = 2$), such as in

a call for future research. The team met regularly and discussed any disagreements until consensus was reached. The final sample consisted of 32 articles.

The lead researcher (VPC) created an analysis codebook, which was informed by the study's conceptual framework and categories used in previous methodological reviews (e.g., Plano Clark, 2010; Plano Clark & Wang, 2010; Stentz et al., 2012). Coding categories included (a) basic article information; (b) content information, such as the discipline and study purpose; (c) information about the quantitative and qualitative strands, such as sampling, data collection, and analysis techniques; (d) the mixed methods features, such as reasons for mixing and timing; (e) the longitudinal features, such as study duration and number of repeated measures; (f) the longitudinal mixed methods design; (g) issues, such as those involving attrition; and (h) analysts' reflections.

Before beginning their coding, analysts (NA, YZ, and JW) reviewed the codebook along with one article that the lead researcher coded as an example. The lead researcher then chose one article for the analysts to code independently. After reviewing their analyses and providing feedback, the lead researcher divided the remaining 30 articles among the analysts for coding. The lead researcher and one analyst independently coded each study. The analyst entered the relevant information, including direct quotations from the articles, into a Google spreadsheet, and the lead researcher reviewed the information, added her comments and reflections, and provided feedback. Any discrepancies were discussed until agreement was reached. The analyst and the lead researcher both drew a diagram of each study showing relevant longitudinal design features (i.e., the number and timing of repeated measures) and mixed methods features (i.e., timing and integration of the qualitative and quantitative strands). The diagrams were compared and discussed until agreement on the flow of the study's methods was reached. Finally, we classified each article's overall design using the models provided by Van Ness et al. (2011): prospective, retrospective, or fully longitudinal. We added an "other" category for designs that did not fall within one of these three design possibilities.

Once the articles were coded, the team quantitatively and qualitatively analyzed the information for each major category using the article as the unit of analysis. Quantitative analysis focused on counting and descriptive summaries. Most of the analysis was more qualitative in nature, where the analysts used open coding strategies to identify patterns in the information and build larger themes. The primary analyst for each category prepared a summary that was shared with the team and team members provided feedback. The analysis continued until all team members agreed that their interpretations were represented adequately in the results.

Results

Ninety-four articles were identified in the search of the PubMed database, and 32 were complete reports of longitudinal mixed methods empirical studies. The search terms were used separately to describe different aspects of the studies' procedures in 15 articles. In the other 17 articles, the terms were used in tandem and suggested the use of an overall hybrid design, such as "a 5-year longitudinal, mixed-methods approach" (Suárez-Orozco et al., 2010, p. 602). The earliest example we located was published in 2005, and the trend in the occurrence of the terms is depicted in Figure 1. The graph indicates an increasing usage of the combined presence of the mixed methods and longitudinal terms in study titles/abstracts, as well as an increasing trend in the number of actual longitudinal mixed methods empirical articles. We begin with a brief summary of the articles and then focus our results on describing the variations found within the studies in terms of the purposes, designs, and issues that emerged.

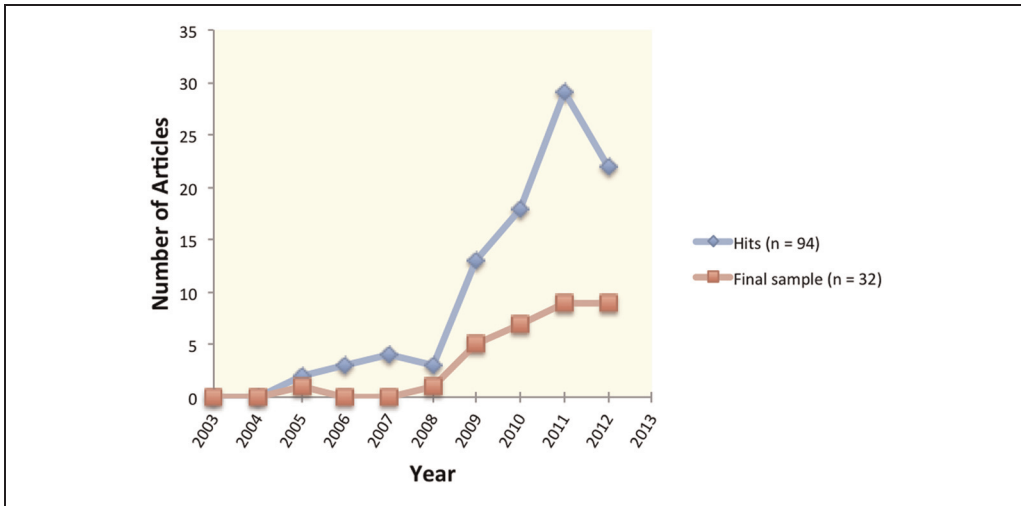


Figure 1. Search results: Number of hits and identified longitudinal mixed methods articles by year.

Basic Information About the Articles

The 32 articles were published in 30 different journals representing diverse fields including nursing, public health, health services research, gerontology, mental health, psychology, and education. The research was often conducted and reported by teams (the number of authors ranged from 1 to 11, with $M = 5.1$, $SD = 2.7$). Only three articles were authored by a single researcher. The majority of articles ($n = 20$) included authors from the United States. Four articles included researchers from Sweden, and three included researchers from the United Kingdom. Authors were also from Australia, Belgium, Canada, Ethiopia, Hong Kong, Japan, and the Netherlands. Three pairs of articles reported data from the same larger studies.

Purposes and Rationales for a Longitudinal Mixed Methods Approach

With the diverse topics and disciplines in the reviewed studies, the study purposes were varied. Notably, two thirds of the articles ($n = 21$) investigated an intervention, such as a creative arts therapy for pediatric patients undergoing treatment for brain tumors (Madden, Mowry, Gao, Cullen, & Foreman, 2010), a school-based cognitive-behavioral group therapy for aggressive bully victims (Fung, 2012), and a community partnership intervention to build community knowledge of evidence-based programs (Crowley, Greenberg, Feinberg, Spoth, & Redmond, 2012). In these articles, the study purposes focused on evaluations of the intervention, such as its effectiveness, impact, or feasibility. In the articles with no intervention, the purpose was to describe or to explore the association among variables or the unfolding of an experience over time. For example, Evans, Belyea, and Ume (2011) intended to “describe how two empirically real cases of [Mexican American] males came to provide personal care for their aging mothers and how that experience unfolded over the 15-month course they were in our study” (p. 235).

We also examined the authors’ rationales for using the mixed methods and longitudinal approaches. Just over half of the articles ($n = 18$) included an explicit rationale for using mixed methods. Reasons expressed for the need to mix methods included to better evaluate an intervention, to corroborate results, to capture the complexity of the phenomenon, and to enrich the interpretation of one type of result with the other type. For example, Teti et al. (2010) explained,

“Using both quantitative and qualitative methods allowed us to capitalize on the advantages of each method to obtain a more in-depth understanding of the effects of the intervention, as well as women’s experiences within it” (p. 568). Unremarkably, most authors’ rationale for including a longitudinal aspect in the study was the need to examine patterns of change over time. Different from the rationales provided for mixing methods, several of the authors argued that the longitudinal approach was needed to address a gap in the literature.

Describing the Longitudinal Mixed Methods Designs

Based on the studies’ procedures, we classified each in terms of Van Ness et al.’s (2011) three models, as shown in Table 1. Contrary to Van Ness et al.’s expectation that prospective and retrospective approaches would be the most common approaches, we found that 75% of our sample reported approaches that did *not* fit these two categories. Nine studies were classified as fully longitudinal; 15 were classified as “other” because they did not meet the definitions of any of the three models. Because our goal was to describe the variety in the approaches used, we noted salient variations that occurred within the categories, which are provided in Table 1. From these variations, we identified several dimensions that differentiated the designs used in the reviewed studies: correspondence, timing, mixing, level of analysis, and use of time. These dimensions are summarized in Table 2 and are highlighted as we discuss the features of the 32 reviewed articles as organized by the design variations.

Prospective Longitudinal Mixed Methods Design. One article used an approach consistent with the prospective longitudinal mixed methods model. As summarized in Figure 2, Karlström et al. (2011) gathered quantitative data about women’s preferences for delivery method at four time points (twice during pregnancy and twice after birth). At the first time point, they gathered qualitative data in the form of one open-ended question to elicit the women’s comments about their delivery preferences. Therefore, the qualitative data were gathered concurrently with the initial quantitative time point. The authors analyzed each data set separately and merged the two sets of results by linking themes that emerged from the qualitative data analysis to the quantitative preferences results and by drawing overall interpretations of the complexity of women’s preferences for delivery method and the reasons for these preferences and changes in the preferences.

Retrospective Longitudinal Mixed Methods Design. We classified seven articles as having used a retrospective longitudinal mixed methods approach. Among this group, we distinguished three variations based on their overall timing (i.e., concurrent, sequential, or combination). Four articles used concurrent timing, consistent with the Van Ness et al. (2011) retrospective model. The researchers in these studies collected quantitative data at multiple time points and qualitative data concurrent with the quantitative data at the study’s final time point. No indication was given that the qualitative data collection was shaped by any analysis of the quantitative data in these studies. The authors integrated their two data sets during analysis and/or interpretation in order to substantiate the quantitative results with the qualitative findings or to qualitatively describe perspectives and experiences with the quantitative results.

In two of the articles using a retrospective approach, researchers used sequential timing. In these studies, the authors gathered quantitative data across three or more time points. They analyzed this data set quantitatively and used the quantitative results to select specific cases for further qualitative investigation. The “retrospective” qualitative component was collected at a single time point after the completion of the quantitative longitudinal strand and did not correspond with any of the quantitative time points. Figure 3 provides an overview of a retrospective sequential approach as implemented by Bradley et al. (2012) to study a health promotion

Table 1. Description of the Longitudinal Mixed Methods Design Variations Used in the Reviewed Articles.

Designs ^a	Number (%)	Variations	Reviewed articles
Prospective	1 (3%)	<ul style="list-style-type: none"> • Concurrent 	<ul style="list-style-type: none"> • Karlström, Nystedt, Johansson, and Hildingsson (2011)
Retrospective	7 (22%)	<ul style="list-style-type: none"> • Concurrent • Sequential • Combination 	<ul style="list-style-type: none"> • Bormann et al. (2009); Brathwaite (2005); Symon, Whitford, and Daltzell (2012); Teti et al. (2010) • Bradley et al. (2012); Gioia and Brekke (2009) • Pettersson, Löfqvist, and Fänge (2012)
Fully longitudinal	9 (28%)	<ul style="list-style-type: none"> • One-to-one correspondence • One-to-many correspondence (effectively fully longitudinal) 	<ul style="list-style-type: none"> • Desplenter, Laekeman, and Simoens (2011); Evans et al. (2011); Evans, Belyea, Coon, and Ume (2012); Molony, Evans, Jeon, Rabig, and Straka (2011); Suárez-Orozco et al. (2010) • Dierick-van Daele et al. (2010); Kamei et al. (2011); Lukas et al. (2010); Wallen et al. (2012)
Other	15 (47%)	<ul style="list-style-type: none"> • Circumspicive (qualitative data collected at mid time point) • Book ends (qualitative data collected at first and last time points to study change) • Less-than-fully longitudinal (arbitrary pattern) • Conversion (becomes fully longitudinal after quantizing qualitative results) • Multiquestion/level (longitudinal for one or more aspects/levels) 	<ul style="list-style-type: none"> • Ellis, Marsh, and Craven (2009); Park, Chang, Quinn, Regan, et al. (2009a); Park, Chang, Quinn, Ross, & Rigotti (2009b) • Bradley et al. (2011); Turner-Cobb et al. (2010) • Harr, Dunn, and Price (2011); Hult, Wrubel, Bränström, Acree, and Moskowitz (2012); Macpherson (2008); Nijland, van Gemert-Pijnen, Kelders, Brandenburg, and Seydel (2011) • Adolfsson, Granlund, Björck-Akesson, Ibragimova, and Pless (2010); Crowley et al. (2012) • Andreatta, Saxton, Thompson, and Annich (2011); Fung (2012); Hussaini, Hamm, and Means (2012); Madden et al. (2010)
Total	32 (100%)		

a. Designs based on the models suggested by Van Ness et al. (2011).

Table 2. Dimensions That Differentiate Longitudinal Mixed Methods Designs.

Dimension	Brief description	Options used in the reviewed articles
Correspondence	Relationship of the time points for gathering the quantitative and qualitative data	<ul style="list-style-type: none"> • None • First • Last • Middle • First and last • One-to-one • One-to-many • Arbitrary
Timing	Relationship of the occurrence of the quantitative and qualitative strands	<ul style="list-style-type: none"> • Concurrent • Sequential • Combination
Mixing	When and how the quantitative and qualitative strands are integrated	<ul style="list-style-type: none"> • Connecting results of one phase to data collection of next phase • Comparing quantitative and qualitative results • Synthesizing complementary results • Conversion/data transformation • Typology development
Level of analysis	Extent to which the data are analyzed at the individual or group level	<ul style="list-style-type: none"> • Individual participant or cases • Group(s) or subgroups • Individual and group(s)
Use of time	How time is incorporated into the analysis and integration	<ul style="list-style-type: none"> • Not considered • As a continuous, ordinal, or categorical variable/construct • During quantitative and/or qualitative analysis • During integration of quantitative and qualitative results • During interpretation of quantitative and/or qualitative results

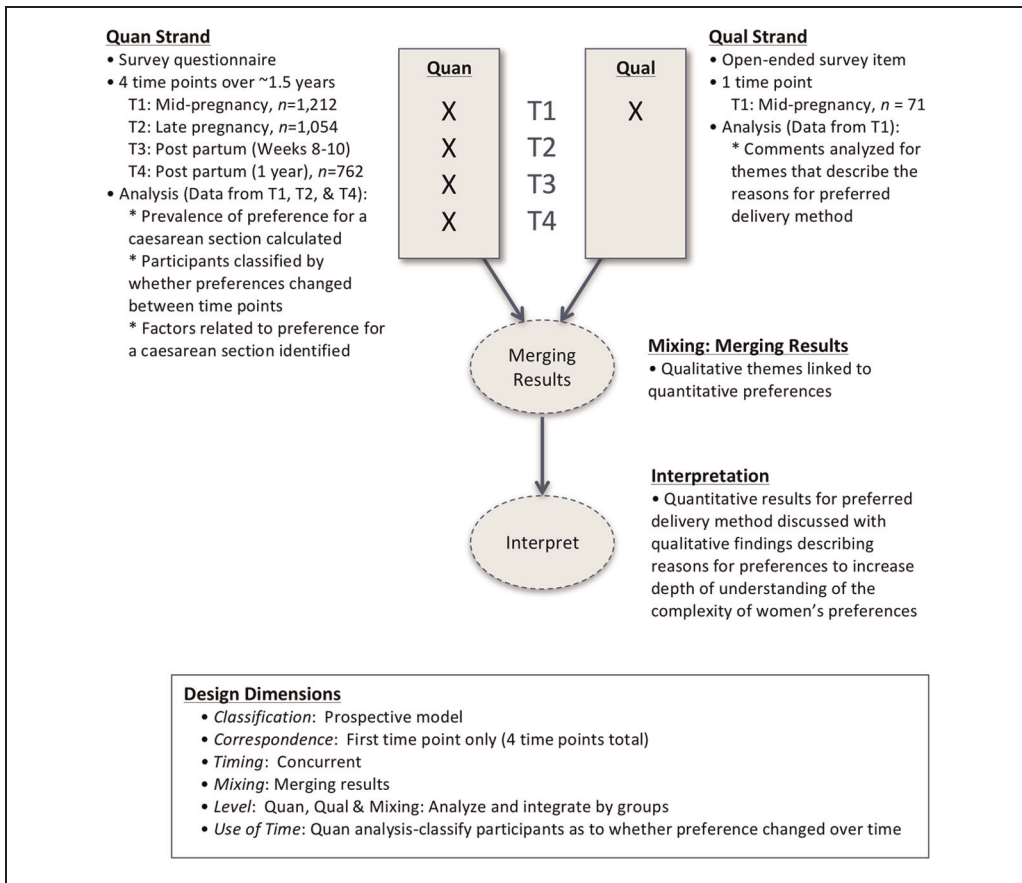


Figure 2. Flow of the methods in a prospective longitudinal concurrent mixed methods design.
 Note. Diagram based on study by Karlström et al. (2011).

intervention in Ethiopia. Although this variation can be considered a “typical” sequential explanatory mixed methods approach (Creswell & Plano Clark, 2011), it was interesting how the longitudinal aspect of the initial quantitative phase was incorporated to enhance the connection between the two phases. Bradley et al. (2012) used the results of quantitative longitudinal regression analyses to purposefully select the cases that demonstrated the highest, lowest, and most-improved performance over time for qualitative study.

The authors of one retrospective longitudinal mixed methods study combined sequential and concurrent aspects into their design. Pettersson et al. (2012) analyzed their quantitative data from 131 participants over three time points to select four cases for in-depth study (the sequential aspect). When they returned to the four cases to gather qualitative data, they gathered the quantitative data for a fourth time (the concurrent aspect). In presenting their results, they reported their four case descriptions as chronologies and embedded the longitudinal quantitative information to enrich their descriptions and interpretations over time.

Fully Longitudinal Mixed Methods Design. Methodologically speaking, we found the nine articles classified as using a fully longitudinal approach to be the most interesting and often the most clearly described despite their inherent complexity. Perhaps this clarity results from the high

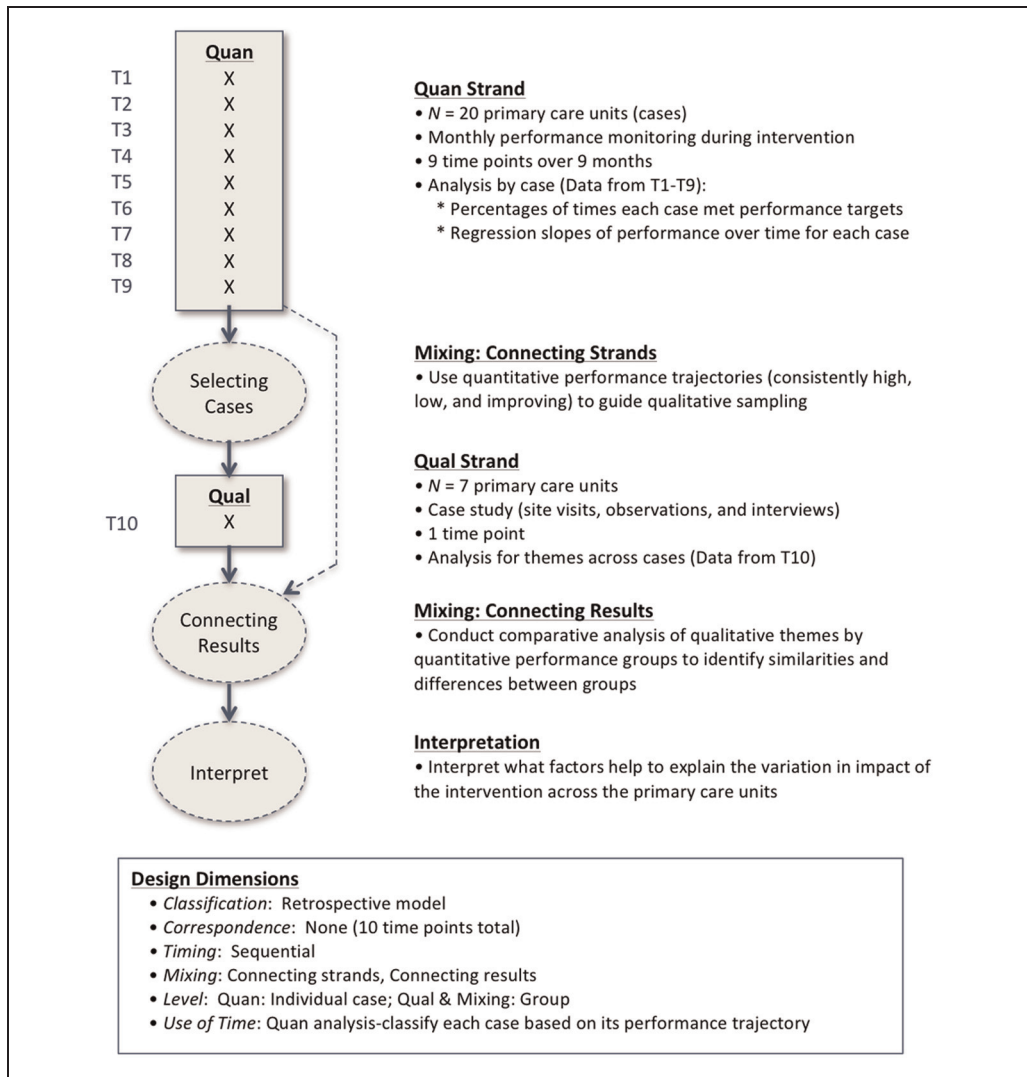


Figure 3. Flow of the methods in a retrospective longitudinal sequential mixed methods design. Note. Diagram based on study by Bradley et al. (2012).

level of planning and organization that occurred when the researchers designed their study to include repeated gathering of quantitative and qualitative data at multiple time points from the start. Two variations emerged within the studies classified as fully longitudinal based on the extent of correspondence between the quantitative and qualitative time points.

Five studies used a one-to-one correspondence, consistent with Van Ness et al.’s (2011) description of the two data types being collected at “each and every” (p. 299) time point in fully longitudinal designs. In these studies, the authors gathered the two sets of data at 4, 5, or 6 time points for a duration that ranged from 6 months to 5 years. Figure 4 provides an example of one-to-one correspondence in a fully longitudinal approach as applied in Molony et al.’s (2011) study of nursing home residents’ feelings of being at home. The other four fully longitudinal studies captured the essence of the fully longitudinal design by systematically collecting

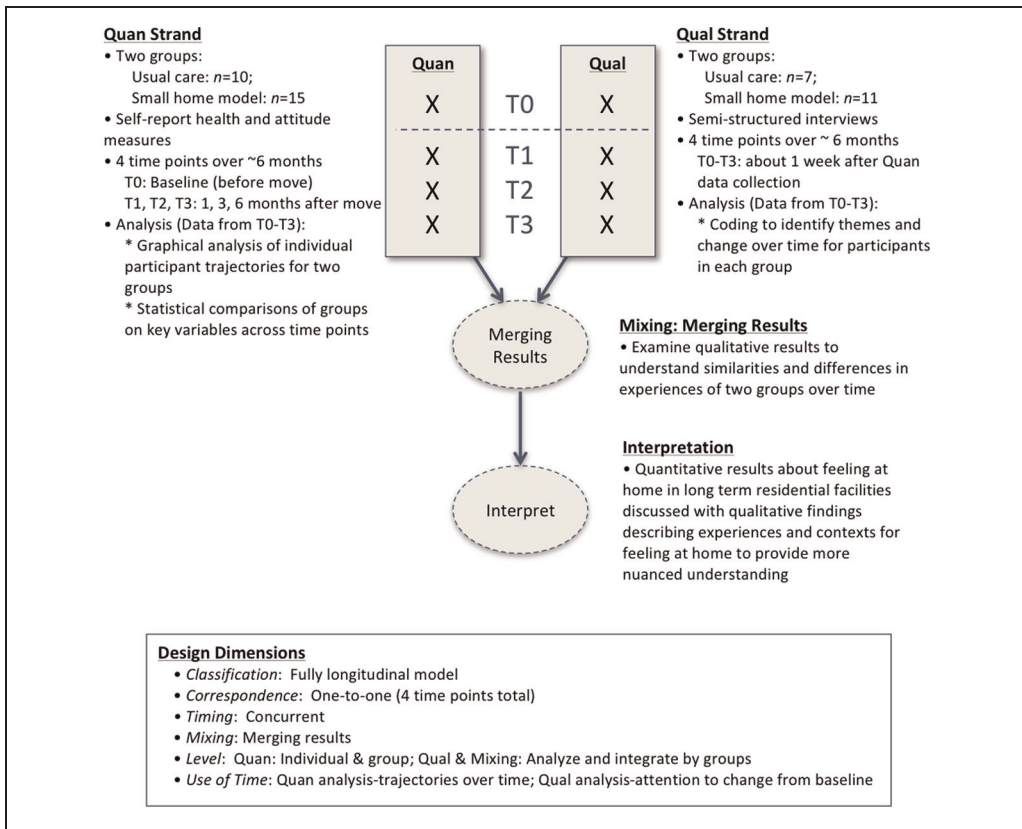


Figure 4. Flow of the methods in a fully longitudinal mixed methods design.

Note. Diagram based on study by Molony et al. (2011).

both quantitative and qualitative data throughout the study, but used a different time scale for the two data sources resulting in a one-to-many (or many-to-one) correspondence. For example, Wallen et al. (2012) administered quantitative measures at seven time points and gathered qualitative data at every other quantitative time point for three qualitative time points total. Kamei et al. (2011) gathered quantitative measures at three time points and conducted qualitative observations at 22 corresponding time points across the same study period.

Several of the fully longitudinal mixed methods studies attempted to gather the quantitative and qualitative data from the same sample; others chose to include only a subsample in the analysis and results reported in the reviewed article. For example, Suárez-Orozco et al. (2010) collected both forms of data from a sample of newcomer immigrant youth that ranged from 407 at Time 1 to 309 at Time 5. Although they analyzed the quantitative data from all participants, they chose to analyze the qualitative data gathered from a subset of 75 participants and reported in-depth qualitative results from five participants selected to best illustrate the groups that emerged from the latent growth curve analysis of the quantitative data. The reviewed fully longitudinal studies analyzed the two data sets separately and merged them either during analysis or during the final interpretations and discussions.

Other Longitudinal Mixed Methods Designs. Unexpectedly, almost half of the reviewed studies did not fit the three models suggested by Van Ness et al. (2011), even with the expanded variations discussed in the prior sections. We classified these 15 studies as “other” and examined

them to identify patterns within their procedures. The emergent dimensions included the correspondence of the quantitative and qualitative data collection time points, the approach to mixing, and the number of questions or levels in a system being studied. Five general patterns of variations emerged, adding to the complexity of options available. In the subsections that follow, we suggest names and brief summaries of these emergent categories as a means of describing the variations we found in the reviewed studies.

Circumspective variation. Three articles gathered qualitative data at one time point that occurred in the midst of the longitudinal quantitative data collection. We call this the circumspective variation because it permitted researchers to “look around” an aspect of the process of interest as it occurred (as opposed to examining participants’ expectations or recollections about the process using a prospective or retrospective approach). The timing of this collection was aimed at best understanding perspectives about an intervention (Ellis et al., 2009) or examining the occurrence of a specific trigger event (e.g., smoking relapse) as closely as possible to when it happened (Park, Chang, Quinn, Regan, et al., 2009; Park, Chang, Quinn, Ross, et al., 2009).

Bookends variation. In two studies, researchers reported gathering qualitative data at both the beginning and end of their longitudinal quantitative data collection so that the two qualitative time points appeared like bookends. This variation can be considered as combining the prospective and retrospective models, although it also permits researchers to use the qualitative data to assess change in addition to describing expectations and recollections. By gathering the two points of qualitative data, the researchers were better positioned to analyze the qualitative data to depict change from the beginning to the end of the study and to merge that information with the quantitative longitudinal results (e.g., Turner-Cobb et al., 2010).

Less-than-fully longitudinal variation. Four studies in the “other” group could be characterized by terms such as less-than-fully, not-quite-fully, or variable longitudinal mixed methods designs. These studies included an unequal number of time points for collecting quantitative and qualitative data, but the pattern appeared more arbitrary than systematic. These studies had little-to-no correspondence between the quantitative and qualitative time points, generally gathering only one type of data at any one time point and gathering several different types of quantitative and qualitative data forms over the course of the study. Unfortunately, the reasons for the data collection patterns were not explicitly explained in the reviewed articles; they seemed to be based on logistical concerns (e.g., gather different data types at different times to reduce participant burden), the need to address different aspects of a phenomenon over time, or the decision to add new data forms as the study progressed. For example, Harr et al. (2011) gathered quantitative data to assess intervention outcomes with pretest, posttest, and 4-month follow-up assessments. Qualitative data were gathered during the intervention (eight repeated interviews) to understand the process and at a 1-year follow-up interview to obtain the participants’ reflections on the overall experience and change.

Conversion variation. Two of the studies used a mixed methods conversion (Teddle & Tashakkori, 2009) approach in the context of their longitudinal study. For example, Crowley et al. (2012) studied the impact of their intervention by matching 28 selected communities and randomly assigning them to either a treatment or control condition. During the 6 years of the study, the researchers gathered annual qualitative, open-ended interviews from a total of 422 leaders in the communities in their treatment and control groups. They developed and described four major categories from the analysis of the qualitative data. Once the categories were developed, they quantified the qualitative data from each category as representing “expert” or “non-expert” views (i.e., a dichotomous variable) thereby creating four quantitative variables for each time point. They used these quantitized variables to statistically and graphically compare the treatment and control groups. Although the initial longitudinal data collection included only

qualitative data, through the analysis and conversion process, the researchers analyzed and reported a fully longitudinal data set to understand the impact of their treatment.

Multiquestion/level variation. Four studies incorporated the longitudinal and mixed methods aspects to address multiple questions or multiple levels in a system, often in an evaluation framework. For example, Hussaini et al. (2012) evaluated the multiple prongs of their community-based intervention by gathering (a) qualitative longitudinal focus group data from African American adults in the community to evaluate a social media campaign; (b) quantitative pre-/posttests from attendees at community-based presentations; and (c) quantitative pre-/post-/follow-up assessments from presentations to health professionals. This study included both qualitative and quantitative longitudinal information, but each data set addressed a different aspect of the evaluation. The studies in this category tended to analyze the data sets separately to address different questions and mix when drawing conclusions about the overall intervention's effectiveness.

Issues Associated With the Use of Longitudinal Mixed Methods Approaches

In addition to describing the design procedures reported in the reviewed articles, we identified issues associated with the authors' longitudinal mixed methods approaches. Many of these issues were discussed explicitly by the authors, but some emerged through our own attempts to understand the decisions made within the studies. As we analyzed the issues, we organized them within the stages of the research process (sampling, data collection, analysis and integration, and reporting), but we acknowledge that some occur across several stages.

Participants and Sampling Issues. Several issues emerged regarding participants including recruitment, sampling, and sample sizes. Authors of several studies attributed recruiting challenges to the longitudinal nature of their studies. Van Ness et al. (2011) raised important concerns about combining random and purposeful samples because of the implications for making statistical inferences in longitudinal mixed methods studies. However, none of the studies in our review used random sampling for the quantitative strand; they all used a form of convenience or purposeful sampling to identify sites, cases, and participants. Sample selection typically involved identifying accessible volunteers who met a specific set of inclusion criteria based on demographic, geographic, and/or health characteristics. As Suárez-Orozco et al. (2010) noted, "Random sampling was not possible given the specific inclusion criteria of the study, the need for signed permission forms from school personnel and parents, and the required commitment of 5 years of participation" (p. 615).

One significant challenge that occurred during our review was determining the actual sample sizes used in the studies. This issue was complicated by the fact that many articles reported data from a subsample of a larger study; used different samples for each data source; and/or had different sample sizes at each time point because of attrition or missing data. A few studies provided clear information about the sample sizes throughout the study but many did not. For the sample sizes that we were able to determine, no clear patterns emerged for describing the sizes that were used. They reflected the study purpose and participant availability. Some articles focused on a small number of cases (e.g., two Mexican American caregivers or four clients who had received housing adaptations). In contrast, other studies included large samples of participants (e.g., 1,212 women), and most fell between these values. The majority of studies used the same participants and the same sample sizes for both the quantitative and qualitative data collection. In nine of the articles, the researchers used a subsample of the quantitative participants for the qualitative component, but in some cases that subsample was still relatively large (e.g., 75 participants).

When larger samples were used, many of the studies noted that the sample size changed over time due to attrition or missing data. For example, Karlström et al. (2011) started with $n = 1,212$ in their quantitative sample at Time 1 but ended up with about $n = 762$ at Time 4. Molony et al. (2011) noted that 72% of their qualitative sample completed at least two interviews across the four data collection points, suggesting a substantial amount of missing data. Many authors had to deal with participant dropouts and resulting missing data issues. Death, disease progression, school closures, household moves, and being too busy were all reasons for participants leaving the studies before the end of data collection. Some attrition rates were quite high, reaching 40% or more in several studies.

Data Collection Issues. As challenging as we found it to identify the samples in these studies, it was even more challenging to identify parameters of the data collection such as the number of waves, the timing of the waves, and the data that were collected at each time point. Most of the studies gathered their data over 4 or 5 time points, with only a few studies including more than 10 time points. The number was difficult to classify because studies varied in how clearly they reported this information. For studies that clearly articulated the collection of data over multiple waves, one particularly helpful strategy was the inclusion of a visual that identified the data collection methods used at each of the study's time points. Authors made creative use of both tables (e.g., Table 1, Macpherson, 2008) and figures (e.g., Figure 1, Turner-Cobb et al., 2010) to present this information. The use of visuals was one of the most effective strategies for clearly conveying the mixed methods and time aspects of the research.

Even when the authors provided extensive information about the timing of data collection, it could still be complicated to describe and categorize. Time points that were defined by the researcher were generally easier to classify, but still could be problematic if participants did not complete all the planned time points. Language issues emerged, such as a study that described collecting data monthly for 18 months but had a total of 19 time points. Some studies had time points that were defined by the participants, which made it even more of a challenge for authors to describe. Park, Chang, Quinn, Regan, et al. (2009) and Park, Chang, Quinn, Ross, et al. (2009) gathered their qualitative data when they first learned that a participant had resumed smoking. Lukas et al. (2010) let each case determine when and how the quantitative data would be collected consistent with their theoretical model for transforming organizations. Nijland et al. (2011) used longitudinal logs of when participants initiated certain events over the Internet. Defining the data collection waves was complicated as researchers gathered primary and secondary forms of data on different time schedules and changed or added measures as the study progressed. We also needed to carefully differentiate the repeated collection of qualitative data from more typical prolonged engagement in a setting that occurred over time but did not include a repeated, longitudinal element.

Some of the issues reported by the authors were consistent with those raised by Van Ness et al. (2011) regarding bias and participant burden in longitudinal research generally and the fully longitudinal model in particular. Whereas Van Ness et al. (2011) warned that repeated qualitative data collection could bias statistical results, Evans et al. (2012) wrote that their participants' qualitative interview responses might have been influenced by the battery of standardized measures that were administered prior to the interviews at every time point. Van Ness et al. (2011) also noted that the collection of qualitative and quantitative data at each time point could overburden participants. In the studies we examined, some researchers had adjusted their data collection protocols to decrease this burden. Molony et al. (2011) collected qualitative data 1 week after the quantitative data in each wave so as not to overburden the participating nursing home residents. Wallen et al. (2012) included a semistructured qualitative questionnaire because it was less burdensome than a long quantitative measure would have been on the participating

palliative care patients. Symon et al. (2012) found that communication with participants through text messages reduced burden and the intrusiveness of the study over time.

Data Analysis and Integration Issues. We were especially interested in issues associated with how authors analyzed and integrated their extensive longitudinal data sets. The authors used several strategies for conceptualizing time for the longitudinal aspect of their studies. Time was treated as a continuous variable (i.e., acknowledging differences in the time between time points), as an ordinal variable (i.e., time is treated as the wave number of 1, 2, 3, etc., even if time between waves was unequal), and as a categorical variable (e.g., collapsing multiple waves into categories such as “pre” and “post”). Despite the importance of time for all of these studies, we found little to no explicit discussion of how time was treated in the analyses.

The quantitative analysis strategies fell within two categories: those focused on single cases/participants and those focused on groups. When analyzing the quantitative data for single cases, researchers used descriptive techniques including applying graphical visual analysis, calculating change scores between time points, assigning cases to groups/profiles based on individual scores, and ranking cases by regression-line slope values. When analyzing the quantitative data for groups, researchers used a wide range of cross-sectional (e.g., descriptive, chi square, effect sizes, analysis of variance, and *t* tests) and longitudinal (e.g., repeated measures analysis of variance, mixed-effects regression models, longitudinal path modeling, latent class growth modeling, and survival analysis) inferential statistical procedures. Researchers made extensive use of tables and figures to summarize their results including graphs of how variables changed over time and tables that reported summary information either by time points or across time, such as regression results.

The strategies used for the qualitative analyses were not as varied as with the quantitative analyses. Most commonly, authors used basic thematic strategies, and several only incorporated illustrative quotes into their reports. Only a few studies explicitly considered time while analyzing the qualitative data. Kamei et al. (2011) used thematic coding to track how a process unfolded over the 22 observational sessions, reporting a description of each theme and when it occurred in relation to the time points. Pettersson et al. (2012) developed case descriptions organized by the time points. A few articles associated qualitative information with data collection time points, such as identifying quotes by time point (e.g., Dierick-van Daele et al., 2010). Researchers used visuals to display qualitative results, such as a figure of the emergent themes or tables listing illustrative quotes by themes, groups, and/or time points. No article included a figure that portrayed qualitative results over time.

Attrition and missing data have important implications for data analysis and was a major issue that emerged in our review. Despite its importance, many authors did not discuss potential data analysis issues that may have resulted from missing data. For example, Hussaini et al. (2012) gathered quantitative data at three time points with samples of $n_{pre} = 127$, $n_{post} = 127$, and $n_{follow-up} = 23$. They analyzed only the pre/posttest data, presumably because of the attrition. However, this point was not acknowledged explicitly in the article. Others reported dealing with missing data by excluding participants from the analysis who did not complete the study (e.g., Turner-Cobb et al., 2010). In the case of two articles from a study on smoking relapse, Park, Chang, Quinn, Regan, et al. (2009) and Park, Chang, Quinn, Ross, et al. (2009) assumed in the analysis phase that those who missed a follow-up questionnaire had relapsed. A few authors thoughtfully discussed the issue of missing data and attempted to lessen its potential impact by using certain statistical procedures such as adding a dropout pattern mixture to the analytic model (Wallen et al., 2012) or using hierarchical generalized linear models after considering the nature of the missing data (Teti et al., 2010).

Because these were self-identified mixed methods studies, we expected the authors to integrate the quantitative and qualitative strands. In many of the reviewed articles, integration was minimal with authors simply analyzing and reporting the data sets separately and discussing both sets of results in the final discussion. Some authors made explicit comparisons between the two sets of results. Turner-Cobb et al. (2010) wrote, “Qualitative analysis yielded two themes, relational impact and the passage of time, which are consistent with the pattern of quantitative data and provide further insight into the impact of the experience for the relatives” (p. 900). Harr et al. (2011) concluded that their “qualitative findings illuminated the processes that led to changes in self-determination” (p. 451). A few articles used strategies that integrated the quantitative and qualitative aspects of the study *before* the discussion. One strategy was to align the results of the two databases for reporting purposes. For example, Bradley et al. (2011) explained: “We report themes that are pertinent to the quantitative time trend data” (p. 224) and went on to compare the two sets of results. Other integrative strategies used in the articles included data transformation (Caracelli & Greene, 1993), where qualitative thematic results were quantified and the new quantitative variables were used in subsequent statistical analyses (e.g., Crowley et al., 2012). A few studies with small sample sizes embedded the quantitative results within case descriptions to enrich the understanding of the case over time.

The most prominent integrative analytic strategy used in the articles was typology development, where groups determined by one data set were used to examine results from the other data set (Caracelli & Greene, 1993). For example, Hult et al. (2012) qualitatively analyzed their series of three interviews with individuals recently diagnosed with HIV. From their analysis, they developed a typology based on individuals’ process for disclosing their HIV status to others and then analyzed their quantitative data to identify differences among the groups. In other applications of typology development, authors formed groups from the quantitative data and then used these groups to further examine or organize their qualitative data and results. Often the quantitative group classifications incorporated the longitudinal time element of the data in some way. Suárez-Orozco et al. (2010) provided a strong example of this strategy when they used latent growth curve modeling to identify five academic performance trajectories from their 5 years of longitudinal data and then presented themes and one in-depth qualitative case study for each group to illustrate the salient experiences of each.

Feasibility and Reporting Issues. Sprinkled throughout the articles were insights into the demands associated with conducting longitudinal mixed methods research. Van Ness et al.’s (2011) observation that fully longitudinal models are potentially highly demanding of researchers’ time and effort was perhaps reflected in the extensive use of research teams across the studies. Most authors noted that they had received external funding, several from multiple sources. Several articles mentioned issues related to the researchers’ roles in data collection, such as having the lead researcher collect one form of data and a research assistant collect the other (Molony et al., 2011).

Another issue was the vast scope of these projects. Several articles explicitly mentioned plans for additional publications because the scope of the research was too large for one article. Several authors cited additional research from their studies that had already been published (usually in reference to more detailed descriptions of the study’s methods) or that was planned for the future to incorporate more of the available data. Multiple publications from the same study likely are evidence of the time, effort, and resources poured into much of this research.

Discussion

This methodological review indicates that researchers are actively conceptualizing, implementing, and reporting studies that make use of a variety of longitudinal mixed methods approaches

to quantitatively capture trends over time and to provide qualitative contextual understandings of those trends. Although this review examined only the 32 articles that met our search criteria, it is likely that more examples exist within the health sciences and across disciplines interested in processes of change and development such as education, sociology, and psychology, to name only a few. Researchers using this design face numerous issues including recruitment, dynamic sample sizes, attrition, complex data collection procedures, integration challenges, feasibility challenges, and reporting challenges.

Van Ness et al. (2011) stated several assumptions for their discussion of three models drawn from the clinical biomedical research context, including (a) the use of large random quantitative samples with small purposeful qualitative samples, (b) the use of qualitative methods in an adjunctive role, and (c) the combination of statistical inferences with qualitative interviewing. None of the studies we reviewed met all of these assumptions. For example, no reviewed studies reported using a random sample for the quantitative strand, some studies had a clear qualitative priority with the quantitative component serving an adjunctive role, some studies did not include any statistical inferences, and several studies used qualitative observational methods. Although many of the assumptions and associated concerns raised by Van Ness et al. did not directly apply to the reviewed articles, our review indicates that there is no shortage of issues and concerns associated with the use of this approach in practice. Further work should examine additional disciplines to more fully describe the variations being used in practice and the specific issues associated with the different variations.

Despite these many differences, we found the primary dimension distinguishing the Van Ness et al. (2011) models (i.e., the correspondence of the quantitative and qualitative time points) to be a useful starting point for a framework for describing the flow of procedures within longitudinal mixed methods designs. However, this one dimension and three models were insufficient to capture the variations used in published articles. Considering the correspondence of the time points also complicates the overall mixed methods timing used in the designs. Due to the potential for the quantitative and qualitative strands to interact within and across the multiple points of data collection, these designs expand the notion of timing that is a prevalent feature in the mixed methods literature (Creswell & Plano Clark, 2010; Greene, 2007; Morse & Neihaus, 2009; Teddlie & Tashakkori, 2009). The typical timing options of “concurrent” or “sequential” are insufficient to describe the wide array of possibilities for how the quantitative and qualitative strands can relate to each other within these designs. This review uncovered a wide array of decisions that researchers are making when designing their studies using a longitudinal mixed methods approach as illustrated by the many variations that we found. Further work needs to examine the relative merit of the different variations to provide researchers with guidance for weighing the options to produce a high-quality design in their study’s context. Researchers across disciplines clearly would benefit from additional guidance on how to describe, navigate, and select from the many options within longitudinal mixed methods designs.

By limiting the search criteria to articles that authors explicitly identified as longitudinal and mixed methods in their titles and/or abstracts, we aimed to identify a data set for review that would provide insights into the state of the art for using this design in practice. All of the reviewed articles contributed knowledge to their respective fields and were successfully published in a peer-reviewed journal. That said, taken as a group, we were surprised at the overall level of confusion, missing information, and lack of rigor present in many of the articles. Important details about basic methods were missing, unclear, or at times, even contradictory. After reading the articles carefully and critically, one conclusion we reached was that the details of these studies were so complex that researchers did not know how to clearly describe

them, and peer reviewers and journal editors did not insist on such clarity. Further work on how best to report complex longitudinal mixed methods designs is clearly needed.

We were particularly interested in identifying exemplar studies for integrating the three components of quantitative, qualitative, and temporal information. We found that several studies used sophisticated strategies for incorporating time into their analyses and several used sophisticated strategies for mixing the quantitative and qualitative strands. However, few articles did both well, and even fewer mixed in a way that incorporated the time dimension in a meaningful way. Many articles did not fulfill the potential of their extensive data sets and left us wishing that the authors had done more to incorporate the longitudinal and mixed aspects in their analyses and conclusions. We conclude that researchers currently lack practical strategies for analyzing longitudinal qualitative data with respect to time and for integrating quantitative and qualitative strands with respect to time.

Fortunately, several of the studies we reviewed can serve as useful models for conceptualizing, implementing, and reporting a longitudinal mixed methods study. In particular, we recommend readers examine the following articles as potential exemplars: Bradley et al. (2012), Evans et al. (2011), Hult et al. (2012), Kamei et al. (2011), Molony et al. (2011), Suárez-Orozco et al. (2010), and Turner-Cobb et al. (2010). In addition, we offer the following recommendations for researchers implementing a longitudinal mixed methods approach:

- Carefully plan and fully describe the dimensions of correspondence, timing, mixing, level of analysis, and use of time within the study's design. Include expertise in longitudinal quantitative, longitudinal qualitative, and mixed methods on the research team to help negotiate these issues.
- Develop a table or figure that clearly outlines the sample and major quantitative and qualitative data collection for each time point in the study to succinctly and accurately describe the flow of procedures.
- Articulate how time is conceptualized and measured. Resist collapsing longitudinal data into single categories, thereby losing the temporal information.
- When longitudinal qualitative data are collected, incorporate the time dimension into the analysis. At a minimum, note the time point for participant quotes. When appropriate, attend to the development of themes or perspectives within themes across time.
- Be cognizant of missing data and its implications for the quantitative, qualitative, and integrative analyses. Discuss how missing data are handled in the analysis and the implications for the results.
- Think creatively about how to incorporate the longitudinal component when integrating the quantitative and qualitative results. Possibilities include merging the results in terms of quantitative and qualitative patterns over time, developing typologies based on patterns over time, and comparing the different results for each point in time.

Several limitations should be kept in mind when considering these results. Because our search criteria were purposefully limited by the use of the term "mixed methods" and use of the PubMed database, the review did not include all published examples of longitudinal mixed methods research and the results cannot be generalized beyond this sample. Additional dimensions and designs are likely in use. The information about each study was limited to what the authors included in the articles and was necessarily constrained by space limitations. Our interpretations were our subjective readings of these texts and were guided by a conceptual framework that likely was not used by the authors themselves. Our results focus on describing current practices and should not be interpreted as prescribing a set typology of logical longitudinal mixed methods designs.

Despite these limitations, this review highlights both the utility and challenges associated with the use of longitudinal mixed methods approaches in the health sciences. Researchers who apply these designs can use the identified issues to anticipate and address challenges that are likely to occur and to encourage their own creative efforts for integrating the mixed methods and longitudinal aspects of their studies. Future methodological work is needed to provide researchers with practical strategies for designing longitudinal mixed methods studies and analyzing and integrating longitudinal mixed methods data sets. Many important problems today in health, education, and social science require an understanding of how phenomena change over time. Rigorous applications of longitudinal mixed methods designs can provide researchers with a powerful strategy for developing an in-depth understanding of these phenomena.

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