



The Factors of Teacher Attrition and Retention: An Updated and Expanded Meta-Analysis of the Literature

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Building on a previous meta-analysis of the literature on teacher attrition and retention by leveraging studies with longitudinal data and a modern systematic search process, this updated comprehensive meta-analysis synthesizes findings from 120 studies on the factors of teacher attrition and retention. We find the research on teacher attrition has grown substantially over the last thirteen years, both on the factors that are examined as well as the increased specificity and nuanced operationalization of existing factors. Consequently, we expand the conceptual framework to include four new categories of these factors and organize existing and new categories into three broad groups of factors, namely personal, school, and external correlates. We discuss our findings of how these factors are associated with teacher attrition and contrast them with previous findings. We also discuss the policy implications of our findings.

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**The Factors of Teacher Attrition and Retention:
An Updated and Expanded Meta-Analysis of the Literature**

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Abstract

Building on a previous meta-analysis of the literature on teacher attrition and retention by leveraging studies with longitudinal data and a modern systematic search process, this updated comprehensive meta-analysis synthesizes findings from 120 studies on the factors of teacher attrition and retention. We find the research on teacher attrition has grown substantially over the last thirteen years, both on the factors that are examined as well as the increased specificity and nuanced operationalization of existing factors. Consequently, we expand the conceptual framework to include four new categories of these factors and organize existing and new categories into three broad groups of factors, namely personal, school, and external correlates. We discuss our findings of how these factors are associated with teacher attrition and contrast them with previous findings. We also discuss the policy implications of our findings.

Key words: teacher attrition, teacher retention, meta-analysis

Introduction

Education policy in the U.S. has been shaped by more than two decades of research that consistently finds teacher effectiveness to be the most important school-based input into student achievement (Aaronson, Barrow, & Sander, 2007; Chetty, Friedman, & Rockoff, 2014; Kane & Staiger, 2008; Rivkin, Hanushek, & Kain, 2005; Sanders & Rivers, 1996). For example, ensuring every teacher is “highly qualified” was a key requirement of the No Child Left Behind Act, and in 2016 alone, the U.S. Department of Education (DOE) awarded over US\$70 million in Teacher Incentive Grants to fund projects that “promote effective teaching through human capital management systems” (U.S. Department of Education, 2018). Given the importance of teachers to student learning and the large resource investments into teacher recruitment and retention, researchers have built a robust literature on teacher attrition and retention, which has been previously synthesized in both narrative reviews (Guarino, Santibanez, & Daley, 2006) and a meta-analysis (Borman & Dowling, 2008). However, the research literature, policy environment, and teacher labor markets have evolved over the last decade since these reviews were published, and, in response, we present an updated and expanded meta-analytic synthesis, focused on recent developments and new insights from the most up-to-date research on teacher turnover.

In tandem with ongoing resource investments and policy interest, the research on teacher turnover continues to grow, because teacher attrition remains a salient and costly issue for schools. The average teacher turnover rate in recent years is around 15% across all public schools, with higher rates in urban schools and schools with more economically disadvantaged students (Ingersoll, 2001; Keigher, 2010). High levels of teacher turnover is concerning because increased turnover rates have been shown to be negatively associated with student achievement, even for students whose teacher did not turnover (Ronfeldt, Loeb, & Wyckoff, 2013). In addition

to detrimental influences on student achievement, particularly for students from marginalized communities, teacher turnover can have substantial monetary costs. A report quantifying the cost of teacher turnover by the National Commission on Teaching and America's Future estimated that districts spend from \$10,000 to \$17,000 for each teacher who leaves the district and calculated that Chicago Public Schools, one of the nation's largest urban districts, spends approximately \$86 million per year on costs associated with teacher turnover (Barnes, Crowe, & Schaefer, 2007; DeFeo et al., 2017).

In addition to the costs related to teacher attrition, teacher mobility patterns have important consequences for the goal of equitable education for all students. Despite policy initiatives to improve teacher effectiveness in every classroom, the extant research on teacher quality finds strong evidence that schools and districts vary in the quality of their teacher workforce (Boyd, Lankford, Loeb, & Wyckoff, 2005; Lankford, Loeb, & Wyckoff, 2002). Variations in teacher quality can be explained by multiple sources such as teacher preferences and district hiring practices (Engel & Cannata, 2015; Engel, Jacob, & Curran, 2014; Lankford, Loeb, & Wyckoff, 2002). These factors affect the differential sorting of teachers across districts and schools, often resulting in an inequitable distribution of teacher effectiveness. For example, teachers, on average, sort into schools with higher proportions of white and Asian students and their behaviors vary systematically according to their own demographic characteristics (Engel, Jacob, & Curran, 2014; Horng, 2009; Smith & Ingersoll, 2004). Moreover, researchers have found that urban schools, on average, have less qualified teachers than suburban schools (Hanushek, Kain, & Rivkin, 2004; Lankford, Loeb, & Wyckoff, 2002). More generally, research on the distribution of teacher effectiveness finds that the most disadvantaged schools are often

the hardest to staff and are often staffed by lower-performing teachers (Boyd et al., 2011; Ingersoll, 2001; Guarino, Santibañez, & Daley, 2006).

The high costs associated with teacher attrition and the inequitable distribution of teacher effectiveness motivate the need to review the most up-to-date research on teacher turnover. Through a synthesis of the research literature, we contribute to the policy and practice of effective schooling by helping educational authorities to better understand factors associated with teacher turnover. This updated synthesis is also timely because the teacher labor market has changed over the last decade and the research literature has gained new insights in light of this evolution. Notably, research on the long-run trends in teacher quality find that talented women, who would have historically pursued teaching, currently have a wider range of career options and these alternative employment opportunities are often better paying or more prestigious options, thus changing the composition of the teacher labor force (Corcoran, 2007; Hoxby & Leigh, 2004; Ingersoll, Merrill, & Stuckey, 2014). We believe the time is ripe to update our understanding of teacher turnover, given these changes to the teacher labor force.

We make this contribution by updating a previous meta-analysis by Borman and Dowling (2008, hereafter referred to as B&D), which synthesized quantitative studies related to teachers' career trajectories from 1980 to 2005 and summarized the prominent themes of this broad literature. Since its publication in 2008, the meta-analysis by B&D has been foundational to our scholarly understanding of the teacher labor market, particularly around teacher attrition and retention. However, in addition to changes in the teacher labor force since its publication, there are compelling reasons to build upon this work. First, since 2005, the theoretical understanding and empirical evidence on determinants of teacher turnover have expanded. For example, as accountability policies gained prominence under NCLB, teacher evaluation systems have grown

in sophistication and gained more widespread usage in high-stakes decisions about teacher tenure, pay, and dismissal. These developments have been accompanied by research examining how evaluation systems are correlated with teacher turnover, a factor not previously examined by B&D. Second, augmenting the results from B&D with research evidence published after 2005 gives us a novel opportunity to examine whether factors related to teacher turnover remain stable over time. Third, significant methodological improvements in meta-analytic techniques over the last decade have given us new tools to conduct more sophisticated meta-analyses. Given these advances, our aim is to expand on the work of B&D by analyzing empirical evidence from 1980 to 2018 in order to understand what factors are associated with teacher attrition and retention. More specifically, this study asks and answers the following research questions:

- 1) What factors are correlated with teacher attrition and retention?
- 2) To what extent are these factors associated with teacher attrition and retention?

Motivating the Current Study

Our study is motivated, in part, by the proliferation of large longitudinal data systems, subsequent studies based on these new data systems, and important methodological advancement in meta-analytic techniques. The creation of large-scale quantitative datasets has allowed researchers to empirically advance our understanding of teacher labor market dynamics. As B&D noted in their limitations section, there were few data sources that provided long-term comprehensive longitudinal data on teachers' outcomes and as such, dynamic trajectories of teachers' careers are not captured. New studies that rely on large longitudinal data systems help address these prior limitations. For instance, these datasets have allowed researchers to investigate the relationship between teacher evaluation and attrition, a question that was difficult

to investigate without data linking changes in teacher evaluation systems with teacher mobility patterns over time (Simon & Johnson, 2013; Stuit & Smith, 2012).

There have also been substantial changes and advancements to meta-analytic methods in the last ten years, particularly related to the search process, publication bias, and best practices for data analysis. For example, the literature search method in B&D is fairly brief. The number of screened studies was not stated, but the authors only found about 150 studies before they applied their inclusion and exclusion criteria. Moreover, the authors' description of how they searched for grey literature simply stated they used search engines like Google. Current best practice is to report on the exact search phrases and operators (Moher et al., 2009). Moreover, B&D did not determine whether their results would hold if they did not make the strong assumption that multiple estimates within the same study are independent of each other. In other words, current best practices would assume each study could only provide one effect size per determinant, or if pooled, individual's standard errors were estimated differently, accounting for within study correlation or by using robust variance estimation (Borenstein et al., 2009; Hedges et al., 2010). We dive deeper into issues of analytic techniques in the methods section.

In summary, our work adds to and improves upon the B&D (2008) study by expanding the search from 1980 to 2018, adding in more than a decade of research and development on factors correlated with teacher turnover, including teacher evaluation systems, teacher merit pay, school accountability, principal effectiveness, teacher-principal race/gender matching, teacher-student race matching, comprehensive school reform, and research-practice partnership. In short, this meta-analysis enhances the scholarly understanding of what drives teacher attrition and retention and provides the most up-to-date comprehensive review of the field's empirical knowledge on teacher attrition and retention.

Background on Teacher Turnover

We focus on the factors that influence teacher turnover (we use turnover and attrition interchangeably), which includes teachers switching schools and teachers leaving the profession. We adopt a school-centered perspective, meaning that we focus first on whether teachers leave the school. We then transition to an examination that specifies whether teachers are transferring to another school or exiting the profession altogether. To frame our conceptual understanding of turnover, we draw on the five categories of determinants of attrition and retention as defined by B&D and then discuss new categories based on recent research. The full list of empirical factors associated with teacher retention and attrition is presented in Appendix Table 1.

Existing Determinants of Teacher Retention and Attrition

Teacher characteristics. Teacher characteristic variables facilitate our understanding of how teacher background (e.g., gender, race, age, experience, marital status, having a new child) influences attrition and retention. Previous studies suggest that female teachers are more likely to leave teaching than male teachers (Adams, 1996; Ingersoll, 2001), and White teachers are more likely to leave than minority race teachers (Clotfelter, Ladd, & Vigdor, 2008; Harrell et al., 2004). Young teachers and teachers near the retirement age are more likely to leave the profession, producing a U-shaped curve of attrition versus age or experience (Guarino, Santibanez, & Daley, 2006). Marital status and having a new child are also associated with increased odds of leaving the profession (Borman & Dowling, 2008).

Teacher qualifications. Several studies have examined the relative attrition rates between teachers with a graduate degree and those with an undergraduate degree, finding mixed evidence regarding the association between graduate degree attainment and attrition (Boe et al., 1998; Shin, 1995; Smith, 2006). Other studies (e.g., Billingsley, 2004; Imazeki, 2005; Ingersoll,

2001; Stinebrickner, 1998, 2002) have examined the attrition rates for teachers who specialize in science, math, or special education. There has also been recent work examining attrition for those who are alternatively certified (Donaldson & Johnson, 2010; Redding & Smith, 2016) or those with National Board certification (Goldhaber & Hansen, 2009). Teacher ability or scholastic achievement and teacher experience also play an important role in influencing teacher attrition and retention (e.g., Allred & Smith, 1984; Arnold, Choy, & Bobbitt, 1993; Boyd, Lankford, Loeb, & Wyckoff, 2005). Generally, these studies have found that training, experience, ability/achievement, and specialty all influence teacher attrition and retention. Building on this literature, we discuss these relationships in more detail below.

School organizational characteristics. To measure school organizational characteristics, researchers have used several moderating variables, including school location, sector, and size, administrative support, induction and mentoring programs, systems that facilitate teacher collaborations, and opportunities for advancement. Extant research often finds that many of these school organizational characteristics are statistically significant, but their effect sizes are substantively small. However, some factors are both statistically significant and practically meaningful: private schools compared to public schools, level of administrative support, and school mentoring programs for novice teachers. These studies suggest that public school teachers, teachers who have higher levels of administrative support (Anderson, 2007; Boyd et al., 2011), and teachers who receive mentoring are much less likely to leave teaching (Hahs-Vaughn & Scherff, 2008; Redding & Smith, 2016).

School resources. Factors in the school resources category include average class size, student-teacher ratio, expenditures for teacher support, expenditures on teaching resources, and per-pupil spending. B&D (2008) report only a handful of studies that examine these factors,

providing weak evidence regarding the influence of school resources on teacher attrition and retention. Our updated work examines substantially more studies, providing stronger evidence. We also expand the number of school resource factors.

Student body characteristics. Student body characteristics includes three general categories: socioeconomic composition, racial and ethnic composition, and student achievement. Contrary to expectation, B&D did not find that school socioeconomic composition has a large influence on teacher attrition. They find that, on average, teachers who work in high-poverty schools were just as likely to leave as teachers who work in low-poverty schools. However, recent evidence suggests that teachers prefer schools with higher proportions of White and Asian students and their preferences vary systematically according to their own demographic characteristics (Engel, Jacob, & Curran, 2014; Horng, 2009). Relatedly, there is suggestive evidence that teachers are more likely to leave schools where the majority of students are minority race (e.g., Carroll, Reichardt, Guarino, & Mejia, 2000; Dagli, 2012). Student achievement, on the other hand, is a strong predictor of teacher attrition. In particular, teachers are less likely to leave if they work in schools or districts with high or above average achievement levels (Eller, Doerfler, & Meier, 2000; Hanushek, Kain, & Rivkin, 2004).

New Determinants of Teacher Retention and Attrition

We have identified eight new determinants of teacher retention and attrition since B&D published their seminal work on teacher retention and attrition. These new determinants are: (a) teacher evaluation, (b) teacher merit pay, (c) federal policies, (d) principal effectiveness, (e) teacher-principal race/gender matching, (f) teacher-student race matching, (g) school reform, and (h) research-practice partnerships. Below we group the determinants based on how they are conceptually related to each other, and briefly describe each determinant and their theoretical or

empirical contribution to the scholarly understanding of teacher attrition and retention.

Furthermore, based on the employee turnover literature, we also briefly discuss other possible determinants that may drive teacher attrition and retention.

Relational demography. A new area of development in the literature focuses on relational demography, which stems from the literature on representative bureaucracy (Fairchild et al., 2012; Grissom, Kern, & Rodriguez, 2015; Sohn, 2009). Grissom and Keiser (2011) found higher job satisfaction and lower turnover for teachers when there was teacher-principal race congruency. Relatedly, researchers have found that teacher-principal gender congruence predicts teacher satisfaction and turnover (Grissom, Nicholson-Crotty, & Keiser, 2012). Most recently, Nguyen and colleagues (2017) found that teacher-principal race congruence plays a role in teacher turnover in a multi-ethnic school district, but this influence varies by the teacher's race and the school's demographic context. In short, recent research in relational demography suggests that teacher-principal race and gender matching can influence teacher attrition.

Accountability. In terms of external programs from the state that rely on accountability at the teacher or school level, there has been much development in state and federal programs and initiatives that aim to make changes to the teacher labor market. Murnane and Steele (2007) note that accountability policies such as rigorous teacher evaluation systems and teacher merit pay can be used to increase the supply of effective teachers as well as help to create a more equitable distribution of effective teachers across schools. However, many of these policies were newly enacted and varied widely in terms of implementation and management; therefore, their effectiveness was still difficult to assess in the mid-2000s (Murnane & Steele, 2007).

Recent work has highlighted how schools responded to high-stakes teacher evaluation, how evaluation is framed depending on the context, and how teacher evaluation can have a direct

impact on teacher satisfaction (Cullen, Koedel, & Parsons, 2016; Murphy, Hallinger, & Heck, 2013; Peterson, 2000; Weiss, 1999). Moreover, recent studies have examined how accountability policies have affected the teacher labor market. For instance, the Teacher Advancement Program where teachers are eligible for bonus pay and leadership opportunities based on student achievement was established in 1999, but there was not an independent evaluation of its effect on teacher labor markets until after 2005 (e.g. Glazerman et al., 2013; Glazerman & Seifullah, 2012; Springer, Ballou, & Peng, 2014). The Teacher Incentive Fund, initially a \$600 million federal grant established by Congress in 2006 to spur student achievement by developing and implementing performance-based compensation systems in high-need schools, was expanded and supported as part of the American Recovery and Reinvestment Act (ARRA) in 2009. Moreover, other state merit pay programs have been implemented and evaluated in the last 10 years, and recent work has found that merit pay can influence the teacher labor market (Pham et al., 2017). Relatedly, there has also been evidence that federal programs and initiatives do influence the teacher labor market, especially regarding teacher retention decisions (Brownell, Bishop, & Sindelar, 2005; Harrell et al., 2004; Hill & Barth 2004).

Lastly, recent works have found accountability of school administrators, which is often tied to high stakes personnel decisions (Li, 2012), can also influence teacher satisfaction, commitment, and attrition. For instance, Grissom (2011) finds that principal effectiveness is associated with greater teacher satisfaction and a lower probability of teacher turnover. Others have found that teachers' perceptions of school administration, particularly with the principal, have substantial influence on teacher retention decisions (Boyd et al., 2011; Stockard & Lehman, 2004). In sum, teacher evaluation, teacher merit pay, federal policies such as NCLB, and principal effectiveness can theoretically influence teacher retention and attrition.

School improvement. In addition to decades of school improvement efforts, such as comprehensive school reform, there has been a swell of new approaches to and evaluations of school improvement, such as research-practice partnerships, that have a strong focus on teacher development and leadership (Borman, Hewes, Overman, & Brown, 2003; Bryk, Gomez, Grunow, & Lemahieu, 2015; Coburn & Penuel, 2016; Cohen-Vogel, Cannata, Rutledge, & Socol, 2016; Datnow & Castellano, 2001). These school improvement initiatives aim to increase teacher buy-in and develop their capacity as teachers and leaders (Nguyen & Hunter, 2018), which theoretically can incentivize teachers to stay in their school (Guarino, Santibañez, & Daley, 2006; Macdonald, 1999; Shaw, 2016). However, until recently, there have not been rigorous evaluations of how school improvement influences teacher attrition and retention (Heissel & Ladd, 2018; Sun, Penner, & Loeb, 2017). These recent developments in school reform are important factors influencing teacher attrition and retention that require more attention.

Workforce. Workforce is a category of determinants that comes mostly from the employee turnover literature outside of education (Cotton & Tuttle, 1986; Griffeth, Hom, & Gaertner, 2000; Rubenstein, Eberly, Lee, & Mitchell, 2017). These determinants are factors that reflect the employment opportunities inside and outside of teaching, and policies that can influence attrition and retention at the district or state levels, but not related to accountability or school improvement efforts. They include employment rate, teacher salary, non-teacher salary, late hiring, and retention bonuses. The employee turnover literature indicates that the overall employment rate, or alternative job opportunities, generally influences whether people stay or leave their current occupation (Griffeth, Hom, & Gaertner, 2000) and that it could extend to teacher attrition and retention (Barbieri, 2011; Clotfelter, Ladd, & Vigdor, 2011). Late hiring is

also another factor that may relate to teacher attrition (Cotton & Tuttle, 1986; Jones, Maier, & Grogan, 2011). In terms of monetary incentives, potential salary in other professions, teacher salaries, and teacher retention bonuses could motivate or deter teachers from leaving the profession (Griffeth, Hom, & Gaertner, 2000; Rubenstein, Eberly, Lee, & Mitchell, 2017). For instance, researchers have found that higher earnings were negatively associated with attrition (Podgursky, Monroe, & Watson, 2004; Stockard & Lehman, 2004). Elsewhere, others have found that salary increases were associated with teachers' decisions to switch schools (Hanushek, Kain & Rivkin, 2004; Lankford et al., 2002).

Data & Methods

This study is designed to examine the determinants of teacher retention and attrition. To define the eligibility criteria, literature search, data analysis, and reporting conventions, we follow the Preferred Reporting Items for Systematic Reviews and Meta-Analysis standards as defined by Moher et al. (2009).

Eligibility Criteria. The primary studies eligible for inclusion in this meta-analysis needed to meet the following criteria: (a) the sample is comprised of teachers in K-12 education; and the study examines (b) characteristics of individuals in the teaching profession; (c) characteristics of individuals who leave the profession; (d) characteristics of schools and districts related to teacher attrition and retention; (e) compensation policies such as teacher merit pay programs; (f) pre-service and in-service policies that affect teacher retention and attrition; and (g) other characteristics or factors that are related to teacher retention and attrition. As noted previously, this study makes a concerted effort to include studies that employ long-term longitudinal data that can capture dynamic teacher career trajectories and studies that examine state and federal policies aimed at changing the teacher labor market.

Literature Search. We obtained primary studies from searching commonly used economic and general social science databases, including ERIC, WorldCat, ProQuest, JSTOR, NBER and EconLit. Through an iterative process, we created the following search string: teacher AND (attrition OR turnover OR retention OR leav* OR suppl* OR career OR attitudes OR mobility OR commit* OR persist*). We did not restrict the search by date. We also searched for “grey” literature using Dissertation and Thesis Repositories in WorldCat and ProQuest as well as a general Google search for evaluation reports of well-known merit pay programs such as the Teacher Advancement Program (TAP), the Teacher Incentive Fund (TIF), and the Texas District Awards for Teacher Excellence Program (DATE). The search on merit pay program is supplemented by a prior search (Pham, Nguyen, & Springer, 2017). In addition to searching databases, our literature search also included an examination of reference lists and previous reviews of the teacher retention and attrition literature (Borman & Dowling, 2008; Guarino, Santibañez, & Daley, 2006; Wilson, Floden, & Ferrini-Mundy, 2001). Our official search ended July 2018. With these more intensive and updated search methods, in addition to new studies that were published over the last thirteen years, we were able to find several additional studies that previous reviews have missed (Boe et al., 1998; Dolton & van der Klaauw, 1999; Harrell et al., 2004; Kelly, 2004; Texas Ed Agency, 1995).

Studies Meeting Eligibility Criteria. Starting with the results returned from the search of databases and previous reviews, we used a three-phase process to screen for primary studies that meet all eligibility criteria as illustrated by Appendix Figure 1. First, we read the title, abstract, and introduction for all studies identified in the original search. We retained a study if the title, abstract or introduction mentioned that the study contained empirical results pertaining

to teacher retention and attrition or teacher career trajectory. The search results can be found in Appendix Table 2. We screened nearly 26,000 studies.

We examined nearly 26,000 studies to ensure we were inclusive in our search and to not miss potentially relevant studies. This large number of studies represents the substantial literature on teacher attrition and retention. However, the vast majority of these studies are not quantitative analyses of teacher attrition and retention behavior. An additional reason for the large number of initial records is that many of these records are duplicate studies or the same studies with slightly altered titles. Other recent rigorous systematic reviews and meta-analyses have comparable exclusion rates (e.g., Gardella, Fisher, & Teurbe-Tolon, 2017).

In phase two, we were left with 332 studies for full text reading where we independently assessed whether each study fits the eligibility criteria outlined above, erring towards inclusion in this phase. The coders discussed any discrepancies and made exclusion decisions upon consensus. From these studies, we excluded studies that do not have teacher turnover data, studies of teacher intention and not attrition, studies with marginal effects, non-empirical results, and duplicate reports. For multiple reports from the same study (e.g., a dissertation and corresponding journal article or reports from multiple years for the same evaluation), we kept only the most recent publication.

In phase three, we excluded eligible studies if key information such as standard errors for effect estimates could neither be calculated nor obtained from the authors. If the standard error or the t -statistic was not provided, but the significance level was available, we used a conservative estimate of the standard error by calculating the t -statistics for the p -value corresponding to reported significance levels. This is a conservative estimate of the standard error since it provides the largest standard error for a given significance level. At the end of phase three, we were left

with a sample of 120 primary studies representing over 11 million teacher-year observations that met all eligibility criteria, which serves as the analytic sample for this meta-analysis.

Coding Reports

Three coders independently coded relevant information for each of the 120 eligible studies using a common coding schema (Appendix Table 3). One coder coded all the studies while the other two coders split the 120 eligible studies. In other words, each study was coded by two coders with one coder coding all the studies. Treating each cell of our coding matrix as an input, coder agreement occurred in 95% of the cells. Any discrepancy was resolved by consensus among the coders. We describe relevant items in greater detail below.

Determinants of teacher attrition and retention. Our main outcomes of interest are coefficient estimates of the relationship between a factor and measures of teacher turnover (switchers who move from one school to another, leavers who leave the teaching profession, and movers who are the combined form of switchers and leavers) and the associated standard error. We focus on and code determinants of teacher attrition and retention, and not teacher intentions, even though they are sometimes used synonymously, a pervasive problem noted by Billingsley and Bettini (in press). Consequently, there are studies that were included in B&D (2008) that are not included in this study (Dworkin, 1980; Hall, Pearson, & Carroll, 1992; Ingersoll & Alsalam, 1997; Shen, 1997; Whitener et al., 1997). The effect sizes are log odd ratios. When studies report odds ratios, they are converted to log odds ratios with the natural logarithm transformation. When studies report proportions, the proportions are converted to log odds ratios along with the associated standard errors (Borenstein et al., 2009; Borman & Dowling, 2008). For ease of interpretation, these log odds ratios are converted back into odds ratios in the presentation. For

reference, the full list of factors associated with teacher retention and attrition examined in this study is presented in Appendix Table 1.

Analytic Strategy

Our analytic approach follows best practices as presented by Borenstein, Hedges, Higgins, & Rothstein (2009) and Moher et al. (2009) in advancing the seminal work by B&D. Below, we describe analytical decisions in selecting models, accounting for multiple estimates within the same study, reconciling studies that use similar data, and assessing risk of bias from differences in study quality.

One of the first methodological choices for this study was between a fixed-effect versus a random-effects model. The fixed-effect model assumes a common true effect size across all studies, whereas the random-effects model allows the true effect size to vary across studies (Borenstein, et al, 2009). Mechanically, the fixed-effect model assigns weights (W_i) to each study (i) using the inverse of each within-study variance (V_{y_i}):

$$W_{i,Fixed} = \frac{1}{V_{y_i}} \quad (1)$$

In contrast, the random-effects model weights studies using both the within-study variance and the estimated between-study variance (T^2):

$$W_{i,Random} = \frac{1}{V_{y_i} + T^2} \quad (2)$$

For this investigation, a random-effects model is most fitting because substantial variation exists across studies in terms of teacher and school characteristics as well as policies and programs that may influence teacher retention and attrition. Moreover, we do not expect the influence of these determinants to be homogenous across different populations and settings.

B&D (2008) opted to maximize the number of effect size estimates from each study since there were a limited number of studies for some determinants of teacher attrition and retention. If

a study provided multiple estimates under various model specifications, they would keep all of them in their meta-analysis. Even though this modeling choice maximizes the available data and allows them to study some determinants with only a few studies on the topic, it assumes that these effect sizes are statistically independent. This decision could be inappropriate if effect sizes from the same study are not independent and studies providing multiple effect sizes will be weighted more than studies providing only a single effect size. Our preferred model does not assume independence of effect sizes. As an additional check of the robustness of the findings, we also conduct the analyses using robust variance estimation (RVE), which does not require information about the covariance structure of the effect size estimates (Hedges, Tipton, & Johnson, 2010; Tanner-Smith & Tipton, 2014).

Another major decision is the treatment of related effect sizes such as hazard ratios and odds ratios. B&D (2008) also used hazard ratios (from proportional hazards regression for instance) in their meta-analysis. Hazard ratios where the time to event (in this case teachers leaving the school or exit the system) is utilized are not strictly equivalent to odds ratios. However, the two statistics are more or less equal, particularly in terms of the interpretation and direction of the statistics, or the increase and decrease risk of an event happening (Nurminen, 1995). Moreover, when the hazard ratios are small, hazard ratios are a close approximation of odds ratios (Stare & Maucourt-Boulch, 2016), and the vast majority of the hazard ratios for teacher attrition and retention are less than two. Since many studies utilize hazard models in studying teacher attrition, we have opted to keep them in the meta-analysis, but we only used them in a robustness check and not in the main analysis. Moreover, the results of our analysis do not change substantively when we include hazard estimates that are larger than two.

Another relevant issue for our analysis is that many studies frequently combine switchers and leavers and discuss them generally as teacher attrition for two main reasons. The first is that these studies are trying to study attrition from the school's perspective where it matters to individual schools why teachers leave their schools. As such, both leavers and switchers can be thought of as leaving their current school. The second is due to data limitations where researchers cannot always determine if teachers are leavers or switchers. Since a substantial number of papers combine leavers and switchers together and discuss them as teacher attrition, we have also opted to follow this practice, and our main analysis includes studies of both forms of attrition. However, in order to address the conceptual difference between leavers and switchers, a gap in the teacher attrition literature raised in a recent systematic review on special education teachers (Billingsley & Bettini, in press), we also run separate analyses using studies that compare switchers against stayers.

In terms of risk of bias, we opted to use an inclusive approach that includes any and all studies that satisfy that eligibility criteria, which may introduce bias from poorly designed studies or studies of low quality. To address this concern, we used the *quality rating approach* as suggested by Lipsey and Wilson (2001). In this approach, we rated each study holistically using our professional judgment of the quality of the study on a scale of 1 to 5 where 1 has high risk of bias and 5 has low risk of bias. Appendix Table 4 contains the criteria we used to determine our rating. The three coders then discussed their individual ratings until a consensus was reached on a final quality rating for each study. We use these ratings as a robustness check to the main analyses in a meta-regression framework. Moreover, we also summarize the quality of the literature on teacher attrition and retention that are included in the meta-analysis. Due to space, we have included publication bias and meta-regression analyses in the Technical Appendix.

Changes to the empirical literature

As noted previously, some studies from prior reviews are not included because they analyze teacher intention and not observed attrition, or they include only descriptive differences among teachers who stay and those who leave. As such, there are only 26 studies included in this current investigation that were included in prior reviews (Table 1). Among these 26 studies, 85 percent were published in peer-reviewed journals, and the median sample size was 2,690 teachers. Two of these 26 studies utilize at least three years of longitudinal data with a sample size greater than 100,000 observations, and one employs a quasi-experimental or experimental design. Lastly, the median study quality on the subjective rating scale from 1 to 5 is a 2 and the mean is 2.69.

In comparison, there are 94 new studies included in the current investigation. With advances in the search process, we are able to find more primary studies, and about 62 percent are published in peer-reviewed journals. These studies provide a more comprehensive picture of the empirical literature. We note that six of these studies were published before 2005 and were not included in B&D (2008). The median sample size is 9,150 observations, which is substantially larger than the previous estimate. Relatedly, for longitudinal studies with more than 100,000 observations, there are 18 studies or 19 percent of all the studies. Moreover, a third of the studies employ quasi-experimental or experimental designs. The median study quality is a 4 and the mean is 3.45. This measure of study quality indicates that the quality of the primary studies has improved greatly over the last ten years. In sum, these descriptive statistics indicate that the empirical literature of teacher attrition and retention has deepened and grown substantially, as measured by the sample size, the longitudinal nature of the studies, studies employing quasi-experimental or experimental designs, and the quality of the studies. These

differences also highlight the importance and contribution of this meta-analysis to the scholarly study of teacher attrition and retention.

Results

Personal Correlates

Teacher Characteristics. Panel A of Table 2 presents the summary effects for the determinants of teacher attrition and retention for the teacher characteristics category. In comparison to previous reviews, the numbers of studies and effect sizes for each category have increased substantially, in some instances by several factors, and in the area of teacher race, we are able to provide a more nuanced picture.

To start, we find that, across 10 studies, when age is operationalized as a continuous measure, older teachers are marginally less likely to leave than younger teachers. Relatedly, when age is operationalized as a binary comparison of those who are 28 years of age or younger compared to those who are older than 28 years, we observe that older teachers are 0.70 times less likely to leave. Stated differently, for teachers who are older than 28, their odds of leaving their school decrease by 30 percent compared to teachers who are 28 or younger. The findings are comparable when age is operationalized as a binary of 30 years of age or younger. Taken together, these results suggest that many young teachers leave their current school within a few years of entry into the profession.

In terms of gender, in contrast to B&D, we do not find that female teachers are more likely to leave. Across 37 studies, we find that female teachers are just as likely to leave their school as male teachers. There are several potential reasons why our finding conflicts with previous work. One explanation is that with the increased number of studies and estimates, we are better able to provide a more accurate picture of how gender influences attrition. Another

explanation is that the influence of gender on teacher attrition may have shifted over the last ten years (e.g., Barbieri, 2011; Boyd, 2011; Grissom, Nicholson-Crotty, & Keiser, 2012). It is possible that women were more likely to leave historically, but this may have changed in recent years.

In terms of race, we are able to provide a more nuanced picture. We are able to compare the odds of Black teachers, Hispanic teachers, and non-White minority teachers leaving the profession compared to White teachers. Our results show no evidence that Black teachers are more likely to leave than White teachers, but there is evidence that Hispanic teachers and generally non-White minority teachers are less likely to leave. Across 11 studies, we find the odds of Hispanic teachers leaving teaching are reduced by 53 percent compared to White teachers. These results indicate that generally there is no evidence that minority teachers, particularly Hispanic teachers, are less likely to leave than White teachers. Lastly, we find full-time teachers are significantly less likely to leave compared to part-time teachers, and the more satisfied the teachers are with their teaching career, the less likely they are to leave their school.

Teacher Qualifications. One of the most well studied areas of teacher attrition examines teacher qualifications (Panel B of Table 2). First, our results indicate teachers with more academic achievement (as measured by GPA or test scores such as the SAT or the ACT) are slightly more likely to leave than teachers with less academic achievement. The odds that teachers with graduate degrees leaving are not statistically different relative to teachers with only undergraduate degrees. There is limited evidence of National Board certification, Teaching Fellow/TFA, and being highly qualified according to NCLB.

Across 16 studies, we observe the odds of leaving for teachers who have standard certification are 0.53 times less than those who do not. Stated differently, the odds of attrition for

teachers with standard certification are decreased by 47 percent compared to those without standard certification. The results also suggest teachers of STEM and special education subjects may be more likely to leave than those who teach other academic subjects, but the results are not significant using only odds ratios studies (they are significant when we include hazard ratio studies). This speaks to the difficulty schools and districts have in retaining STEM and special education teachers. Lastly, an additional year of teaching experience is not associated with the odds of leaving, but new teachers relative to veteran teachers, are consistently more likely to leave with a 54 percent increase in the odds of attrition.

School Correlates

School Organizational Characteristics. On par with teacher qualifications, there have been many studies looking at the relationship between school organizational characteristics and teacher attrition (Panel A of Table 3). These characteristics range from school size and urbanicity to professional development, induction, and mentoring. In terms of school size, we do not observe that teachers leave larger schools at higher rates than smaller schools. In contrast to previous reviews, there is little evidence that urbanicity plays a role in influencing teacher attrition. On the other hand, we do observe that school levels do influence teachers leaving; the odds of leaving are higher for middle school teachers than for elementary school teachers. In terms of school sector, we find that the odds of teachers leaving at charter schools are higher than for teachers at traditional public schools.

Though the first half of the school organizational characteristics determinants provide some understanding into teacher attrition, the second half of these determinants may provide more policy relevant insights. To start, we observe that teachers are marginally more likely to leave schools with higher student disciplinary problems. Relatedly, schools with a better work

environment as characterized by better facilities and fewer school problems such as disciplines or violence also experience less teacher attrition. In particular, across five studies we observe the odds of teachers leaving schools with better working conditions decrease by nearly a factor of two compared to schools with worse working conditions. Along these lines, we also observe that, across 13 studies, the odds of teachers leaving schools with stronger administrative supports are 0.80 times the odds of teachers leaving schools with weaker administrative supports. Comparable to administrative support, beginning teachers who experience induction and/or mentoring are also less likely to leave than those without any induction or mentoring opportunities. Relatedly, teachers who indicated they had good in-service professional development are also less likely to leave than those without. Surprisingly, reports of higher levels of leadership or collaboration do not seem to influence teacher attrition, but due to the limited number of studies and imprecise estimates of the individual studies, these results are not precisely estimated. Taken altogether, these results suggest that there are many school organizational characteristics that could be used to lower teacher attrition. In particular, lowering student disciplinary problems, improving work environment, increasing administrative support, and providing better professional development and induction/mentoring for beginning teachers are all viable actions that can be taken to reduce teacher attrition.

School Resources. There is little to no evidence that providing classroom assistants or teacher aides reduces the odds of leaving, and neither does reducing class size. Using only studies reporting odds ratios severely limits what we can conclude about the relationship between school resources and teacher attrition as there are more studies that use hazard ratios. Including hazard ratios suggests having classroom assistants is associated with decreased odds of attrition.

Student Body Characteristics. A substantial amount of research has been done in this category over the last ten years. In terms of student achievement, across 10 studies, we observe that the odds of teacher attrition are lower for schools with higher student achievement than schools with lower student achievement (Panel C of Table 3). This result is robust to separating this determinant into an increase in student average test score or comparing high to low performing schools. In terms of the characteristics of the students in the schools, we observe the relationships between percent Black or percent Hispanic students and teacher attrition are not significant. However, the odds of teacher attrition for a percent increase in minority students at the school level are statistically significant, but only with a five percent reduction. In terms of percent free or reduced priced lunch (FRPL), percent individualized education plan (IEP), and schools with the majority of students classified as low socioeconomic status, the results are statistically insignificant. In short, there is little evidence that these factors greatly influence teacher attrition.

Relational Demography. This category is a recent development, theoretically and empirically, in the study of teacher attrition and retention (Grissom, 2011; Grissom, Nicholson-Crotty, & Keiser, 2012; Grissom, Viano, & Selin, 2016). Due to its nascent start, there have been only five studies that examine teacher-principal race and gender congruence or teacher-student congruence and their relationship with turnover and only two use logistic regression. With these two studies, we find the odds of teacher attrition may be smaller when there is congruence relative to incongruence, but the result is insignificant due to a large standard error (Panel D of Table 3). While the linear probability estimates are not comparable with odds ratios for meta-analysis, they also point to a decrease in teacher attrition in favor of congruency (Grissom, 2011; Grissom, Nicholson-Crotty, & Keiser, 2012).

External Correlates

Accountability. This category presents an exciting new development in the literature on teacher attrition with almost all of the studies written after B&D. Accountability contains five distinct factors: teacher evaluation, merit pay, teacher effectiveness, and principal effectiveness (Panel A of Table 4). Across five studies, we find that the practice of teacher evaluation is associated with a decrease in the odds of teacher attrition. This suggests teachers who are assessed or evaluated, even for accountability purposes and not simply informal classroom observations, are not necessarily more likely to leave than those who were not. In particular, one study finds there is a reduction in teacher attrition for teachers who experience a “positive shock” to their accountability score and an increase in attrition for teachers who experience a “negative shock” (Feng, 2010). Relatedly Sun et al. (2017) find a slight increase in the odds of attrition with NCLB in the early years and a decrease in the odds of attrition for the later years, but both of these estimates were statistically insignificant. However, Shirrell (2016) finds that Black teachers were less likely to leave teaching under the first year of NCLB subgroup accountability. In general, these results suggest being assessed and evaluated, even for accountability purposes, does not necessarily increase attrition.

The proliferation and study of merit pay in the past decade have also afforded us new opportunities to examine its impacts on teacher attrition. Most of the studies on merit pay provide linear probability estimates instead of odds ratios, so we present linear probability estimates for merit pay. Using linear probability estimates, we find that merit pay programs reduce the probability of attrition by 1.6 percentage points on average. Additionally, in a subgroup analysis, Hough (2012) finds merit pay greatly reduces the probability of attrition by nearly 15 percentage points in hard-to-staff schools. These results suggest merit pay may have

overall positive effects in terms of attrition and in terms of the composition of teachers in the system, even for hard-to-staff schools.

Related to the issue of merit pay is teacher effectiveness as measured by a composite evaluation score or value-added scores.¹ Our analysis and findings with teacher effectiveness are likely one of the most novel findings in this meta-analysis. Across seven studies, we find that increases in the teacher effectiveness score are not associated with increased odds of attrition. The result suggests a possible decrease in the odds of attrition, but it is not significant unless we include hazard ratios studies in the estimate (Appendix Table 5). In other words, the overall result indicates more effective teachers may be less likely to leave than less effective teachers, where teacher effectiveness is measured and is available to the school and teachers. This result is fairly consistent in terms of whether the increase in effectiveness is measured as a standard deviation increase or the comparison of effective teachers compared to less effective teachers (e.g., Boyd et al., 2008; Feng & Sass, 2017a; Goldhaber, Gross, & Player, 2011; Loeb, Kalogrides, & Beteille, 2012). Additionally, two studies in particular provide further suggestive evidence that poor performing teachers, in the bottom quartile or quintile in terms of value-added scores, are also more likely to leave (Goldhaber, Gross, & Player, 2011; Loeb, Kalogrides, & Beteille, 2012). In short, the results from these studies examining teacher effectiveness indicate the use and availability of teacher effectiveness scores can potentially change the composition of the teacher workforce providing positive effects at both ends of the distribution, keeping the highly effective teachers while removing highly ineffective teachers (e.g., Dee & Wyckoff, 2015).

¹ Since teacher effectiveness can be measured as an overall composite score, standardized composite score, standardized value-added, and high versus low, our result speaks broadly to the association of increases in teacher effectiveness and attrition and not an increase in one standard deviation in teacher effectiveness.

There have also been studies on the relationships between principal effectiveness and teacher attrition. The overall meta-analytic result suggests that a higher principal effectiveness score is associated with decreases in the odds of teacher attrition. Delving more deeply into the study, we note that Beteille et al. (2009) find suggestive evidence that higher principal effectiveness is associated with decreased attrition, with the result being statistically significant for teachers with high value-added scores. Similarly, Grissom (2011) and Redding & Smith (2016) find that higher principal effectiveness is associated with decreased odds of teacher attrition, but both of their results are not significant at conventional levels.²

Workforce. Workforce is a category of determinants that is a recent addition to the teacher attrition and retention literature, and there are only a few studies for each determinant with the exception of salary, which has been studied extensively (Panel B of Table 4). The specific determinants in this category with empirical results are employment rate, late hiring, teacher salary, retention bonus, non-teacher salary, union membership, tenure, and pensions. Unfortunately, as these are nascent areas of research, there are not enough studies to conduct meta-analyses for most of these factors. We note the most practically meaningful factor is late hiring or when teachers are hired after school starts. Since there is only one study, we did not conduct a meta-analysis, but the result suggests that late hiring significantly increases the odds of attrition (Jones, Maier, & Grogan, 2011).

The most studied determinant in this area is teacher salary, but it has been operationalized in various ways in the literature. Most often it is operationalized as increase per \$1,000 (e.g., Feng, 2010; Fulbeck, 2014), but it has also been operationalized as comparing high salary with low salary (e.g., Boe et al., 1998, Shin 1995). We included both of these types together to

² The reason why these two studies are not included in the meta-analytic result is that Grissom (2011) uses linear probability models and Redding and Smith (2016) do not provide standard error for this estimate.

increase the power to detect an effect as B&D were unable to do. Across 18 studies, we find that an increase in salary slightly reduces the odds of teachers leaving the profession (Panel B of Table 4). We note that even though the result is statistically significant, the point estimate is close to one, which indicates that the effect of increasing salary, mostly operationalized as an increase of \$1,000, on attrition is small; the estimates tend to be bigger when salary is operationalized in larger comparisons.

Lastly, a few studies have estimated the relationship between union membership and attrition rates. Across three studies, we find that the odds of attrition for teachers who have union membership are 0.75 times the odds of attrition for teachers who do not belong to unions, but this result is only marginally significant (Kelly & Northrop, 2015; Kukla-Acevedo, 2009; Moore, 2011). Redding and Smith (2016) also have similar findings and the point estimate is comparable; unfortunately, their result for this finding does not have the associated standard error and hence is not included in the meta-analysis. The studies in this category are important venues for the study of teacher attrition, but due to the limited number of studies, there is less certainty about the robustness of the meta-analytic results. Including studies with hazard ratios do provide more information, but generally much more research is needed here to provide a more robust and nuanced picture.

Robustness and Sensitivity Checks

To check the robustness of our findings, we first include hazard ratios along with odds ratios in our estimates and we generally find that our main findings are substantively similar (Appendix Table 5). Here we present only selective findings that are substantively different from the main findings. In terms of teacher qualifications, with more studies, we find teachers with higher ability as measured by test scores or those who attended more selective schools are more

likely to leave. STEM teachers and special education teachers are more likely to leave. In terms of school organizational characteristics, teachers are more likely to leave schools where there are more student disciplinary problems. For school resources, two studies suggest that teachers are less likely to leave when they have adequate teaching materials. Lastly, for the workforce category, retention bonuses may reduce the odds of teachers leaving by eight percent.

In terms of the robust variance estimation (Appendix Table 6), the results are also substantively similar to the main model estimates and the independent effect size estimates. However, some of the results cannot be estimated due to the small number of studies and some results become insignificant since RVE tends to be too unreliable when there are fewer than 10 studies and 20-40 effect sizes (Hedges, Tipton, & Johnson, 2010; Tanner-Smith & Tipton, 2013). Consequently, we have also chosen to not display results that have less than seven studies. When there are sufficient studies and effect sizes, robust variance estimation provides similar conclusions as the other models.

Leavers only. There is also a conceptual concern of using effect estimates that compare leavers and switchers together against stayers. To address this concern, we drop all effect estimates that combine leavers and switchers, leaving only estimates that compare leavers with stayers (Appendix Table 7). The results of using the leavers-only estimates are substantively similar to the main analysis.

Switchers only. Relatedly, we also run a set of models where we retain only estimates that compare switchers with stayers (Appendix Table 8). Conceptually, these findings indicate how various factors influence teachers to switch or move from one school to another but not leaving the profession. In terms of findings that are substantively different, we find that male teachers are slightly more likely to switch schools than female teachers, teachers with graduate

degrees are more likely to switch schools than those without, and teachers are less likely to switch schools in urban areas than teachers in rural areas.

In short, to address issues of having multiple within-study estimates, studies employing hazard ratios and odds ratios, and studies that combine leavers and switchers, issues that are ubiquitous to the scholarly study of teacher attrition and retention, we have run separate models dealing with each issue. We find that, despite these technical and conceptual challenges, our preferred estimates are substantively similar to the various alternate estimates, showing the robustness of the main findings as well as evidence that the conceptual framework we have created can be applied to many forms of teacher mobility.

Discussion and Conclusion

The literature on teacher attrition and retention has matured since B&D conducted their systematic search of the literature in 2005. With more than ten years of additional research and the development of large longitudinal datasets, the research on teacher attrition and retention has expanded, providing more reliable results than before as well as introducing new categories of determinants of attrition and retention. Moreover, more studies are able to use experimental or quasi-experimental designs to provide causal estimates, which are still rare in some subfields such as special education teachers (Billingsley & Bettini, in press). Consequently, in some areas, we find results that contrast with prior findings, and in others, we find a more nuanced understanding of the factors that influence teacher attrition; and perhaps most importantly, we also synthesize novel knowledge about what drives teacher attrition, areas of promising future research, and policy levers that may reduce attrition and improve the teacher workforce.

First, we highlight a few findings that contrast with B&D. With additional studies in the meta-analysis, we find that female teachers are not more likely to leave than male teachers. In

terms of having a graduate degree versus no graduate degree, with more studies and estimates, we do not find an increase in the odds of attrition, and our summary effect is very close to the previous summary estimate. We find that teaching specialty areas such as STEM or special education significantly increases the odds of attrition. In these cases, we suspect there may be two possible reasons why there are contrasting findings: (1) the additional studies provide a more accurate picture of what influences attrition and retention than previously; and (2) the influence of these factors may have changed over time. While we believe that this more rigorous and updated search provides better estimates, we also conduct meta-regressions to see if results from studies published after B&D's work are statistically different than previous results. The bivariate meta-regression results yield no statistical significance, although due to the limited number of studies and effect sizes, we may not have had enough statistical power to detect any such difference (see Technical Appendix).

In terms of where we are able to provide more nuance, first we start with personal correlates or factors associated with the teachers. We find only Hispanic teachers have reduced odds of attrition relative to White teachers when new studies are able to differentiate between Black, Hispanic, and any minority non-White teachers. We also find stronger evidence that teacher satisfaction plays an important role in teacher decisions to leave or stay in teaching. Relatedly, full-time teachers are less likely to leave teaching than part-time teachers. We continue to find teachers with regular or standard certification are less likely to leave teaching than those who do not, and we have limited evidence on how National Board certification or going through an alternative certification program like Teach For America is associated with turnover. In terms of school correlates, we consistently find that middle school teachers are more likely to leave teaching than elementary teachers. We find that various measures of school

characteristics as an organization, namely student disciplinary problems, administrative support, and professional development, strongly influence whether teachers stay or leave teaching. In terms of school resources, we find that providing teaching materials reduces odds of attrition. We find that most school body characteristics do not seem to influence attrition or that their influences are rather small. In terms of external correlates, we find that these factors do influence teacher attrition and retention. Being evaluated, even for accountability purposes, does not necessarily increase teacher attrition; in fact, the odds of attrition for teachers who are assessed are somewhat smaller than those who are not. In terms of teacher effectiveness, higher quality teachers are less likely to exit than lower quality teachers, and there is evidence that teachers in the lowest quartile or quintile of value-added scores are more likely to leave teaching. Relatedly, teachers in merit pay programs are less likely to leave teaching than those who are not.

In addition to providing a comprehensive and quantitative analysis of the factors that influence teacher attrition and retention, this meta-analysis also provides scholars and policy-makers with some policy implications and areas of future research. First, we have some preliminary evidence that suggests providing retention bonuses and limiting late hiring could reduce teacher attrition, although much more research is needed to confirm these findings. Second, we recognize that some specific types of teachers need additional supports or incentives to keep them in the teaching profession. For instance, teachers in their early- to mid-twenties and STEM and special education teachers are particularly at risk for leaving teaching. We have compelling evidence that there are school organizational characteristics, such as student disciplinary problems, administrative support, teacher collaborations, and professional development, which, if improved or strengthened, could substantially reduce the risk of attrition. It is, by no means, an easy feat to simply decrease student disciplinary problems or improve

administrative support, nor is it guaranteed that such actions would necessarily keep young teachers or specialty teachers in teaching, but the evidence suggests that this is a promising area of research. In particular, educators and policy-makers should consider creating school environments where strong administrative support, consistent teacher collaborations, and regular and meaningful professional development could provide young or specialty teachers the resources and support needed to keep them in teaching. While there are some efforts in this regard (Podolsky, Kini, Bishop, & Darling-Hammond, 2016), we need more rigorous evaluations of these efforts.

Moreover, contrary to some concerns about the negative effects of teacher evaluations and accountability (Darling-Hammond, 2013; Darling-Hammond, Amrein-Beardsley, Haertel, & Rothstein, 2012), we do not find that performance evaluations necessarily increase teacher attrition. The extant empirical evidence suggests that when teachers are evaluated and their measures of effectiveness are available to them, this does not increase attrition, but in fact, it may provide teachers with some sense of empowerment and the possibility of growth and improvement since they can observe where they are effective and where they are not, leading to a decrease in attrition (Boyd et al., 2008; Feng, 2010). Furthermore, even when teacher evaluations are being used for accountability, bonuses, or pay raises, we observe that teachers are less, not more, likely to leave teaching. Relatedly, we also have evidence that evaluation and accountability may improve the teacher workforce by keeping the most effective teachers and removing the most ineffective teachers. In short, evaluation and accountability may be perceived more positively by teachers and can have positive effects for teachers than have been recognized. We note this does not mean that there are not any negative consequences or warranted concerns

about teacher evaluation and accountability, but rather as a policy tool, there may indeed be merit to evaluation and accountability.

As the scholarly study of evaluation and accountability and teacher attrition and retention is fairly nascent, much more work remains to be done. For instance, even though merit pay is linked with reduced teacher attrition, we know less about which program characteristics of merit pay are associated with or most likely responsible for keeping teachers in the profession. Moreover, as some of the research on merit pay relies on associational evidence, we do not know for certain if the estimates are unbiased or if there are unobserved factors about the schools and districts that have merit pay that may induce teachers to stay in teaching relative to schools and districts that do not have merit pay. We also have less evidence about whether merit pay programs are attracting more effective teachers. Relatedly, we have less evidence about how teacher evaluation is used such that it may reduce attrition. Lastly, in terms of future research for teacher attrition, relational demography and school improvement are two areas that need development and exploration. We have only a few suggestive studies about the relationship between relational demography and attrition and how school reforms and research-practice partnerships influence teacher attrition and retention.

In conclusion, this meta-analysis has substantially expanded the field's knowledge of teacher attrition and retention by providing more robust and nuanced findings than before as well as providing novel findings that come from recent work. Moreover, it has provided suggestions for policy levers that may be used to reduce teacher attrition as well as areas of future research that would greatly improve the scholarly study of teacher attrition and retention.

References

- *Adams, G. J. (1996). Using a Cox regression model to examine voluntary teacher turnover. *The Journal of Experimental Education*, 64(3), 267–285.
- *Allen, R., & Sims, S. (2017). Improving Science Teacher Retention: do National STEM Learning Network professional development courses keep science teachers in the classroom?. *Wellcome Trust/Education Datalab*.
- *Allred, W. E., & Smith, R. B. (1984). Profile of Utah teachers leaving the teaching profession. *Rural Educator*, 5(3), 2–5.
- *Anderson, L. B. (2007). The effects of induction programs on new teacher retention rates. (Doctoral dissertation). University of Phoenix, Tempe, AZ.
- *Arnold, C. L., Choy, S. P., & Bobbitt, S. A. (1993). *Modeling teacher supply and demand, with commentary (NCES 93-461)*. Washington, DC: National Center for Education Statistics.
- *Barbieri, G., Rossetti, C., & Sestito, P. (2011). The determinants of teacher mobility: Evidence using Italian teachers' transfer applications. *Economics of Education Review*, 30(6), 1430–1444.
- *Barnes, G., Crowe, E., & Schaefer, B. (2007). *The cost of teacher turnover in five school districts: A pilot study*. Washington, DC: National Commission on Teaching and America's Future.
- Bartolucci, A. A., & Hillegass, W. B. (2010). Overview, strengths, and limitations of systematic reviews and meta-analyses. In F. Chiappelli (Eds.), *Evidence-based practice: Toward optimizing clinical outcomes* (pp. 17-33). Berlin, Heidelberg: Springer Berlin Heidelberg.
- *Beaudin, B. Q. (1993). Teachers who interrupt their careers: Characteristics of those who return to the classroom. *Educational Evaluation and Policy Analysis*, 15(1), 51–64.
- *Beteille, T., Kalogrides, D., & Loeb, S. (2009). Effective schools: Managing the recruitment, development, and retention of high-quality teachers. *National Center for Analysis of Longitudinal Data in Education Research Working Paper No. 37*.
- Billingsley, B. S. (2004). Special education teacher retention and attrition: A critical analysis of the research literature. *The Journal of Special Education*, 38(1), 39-55.
- Billingsley, B., & Bettini, E. (in press) Special education teacher attrition and retention: A review of the literature. *Review of Educational Research*.
- *Boe, E. E., Bobbitt, S. A., Cook, L. H., Barkanic, G., & Maislin, G. (1998). *Teacher turnover in eight cognate areas: National trends and predictors*. Philadelphia, PA: University of Pennsylvania, Center for Research and Evaluation in Social Policy.
- *Booker, K., & Glazerman, S. (2009). *Effects of the Missouri career ladder program on teacher mobility*. Washington, DC: Mathematica Policy Research, Inc.
- Borenstein, M., Hedges, L. V., Higgins, J., & Rothstein, H. R. (2009). *Introduction to Meta-Analysis*. Chichester, UK: Wiley.
- Borman, G. D., & Dowling, N. M. (2008). Teacher attrition and retention: A meta-analytic and narrative review of the research. *Review of Educational Research*, 78(3), 367–409.
- Borman, G. D., Hewes, G. M., Overman, L. T., & Brown, S. (2003). Comprehensive school reform and achievement: A meta-analysis. *Review of Educational Research*, 73(2), 125–230.
- *Boyd, D., Grossman, P., Ing, M., Lankford, H., Loeb, S., & Wyckoff, J. (2011). The influence of school administrators on teacher retention decisions. *American Educational Research Journal*, 48(2), 303–333.

- *Boyd, D., Grossman, P., Lankford, H., Loeb, S., & Wyckoff, J. (2008). Who leaves? Teacher attrition and student achievement. *NBER Paper No. 14022*.
- *Boyd, D., Lankford, H., Loeb, S., Ronfeldt, M., & Wyckoff, J. (2011). The role of teacher quality in retention and hiring: Using applications to transfer to uncover preferences of teachers and schools. *Journal of Policy Analysis and Management*, 30(1), 88–110.
- Boyd, D., Lankford, H., Loeb, S., & Wyckoff, J. (2005). Explaining the short careers of high-achieving teachers in schools with low-performing students. *The American Economic Review*, 95(2), 166–171.
- *Boyd, D., Lankford, H., Loeb, S., & Wyckoff, J. (2008). The impact of assessment and accountability on teacher recruitment and retention: Are there unintended consequences? *Public Finance Review*, 36(1), 88–111.
- *Brewer, D. J. (1996). Career paths and quit decisions: Evidence from teaching. *Journal of Labor Economics*, 14(2), 313–339.
- Brownell, M. T., Bishop, A. M., & Sindelar, P. T. (2005). NCLB and the demand for highly qualified teachers: Challenges and solutions for rural schools. *Rural Special Education Quarterly*, 24(1), 9–15.
- Bryk, A. S., Gomez, L. M., Grunow, A., & LeMahieu, P. G. (2015). *Learning to improve: How America's schools can get better at getting better*. Cambridge, MA: Harvard Education Press.
- *Cannady, M. A. (2011). *Modeling teacher attrition: Teacher characteristics and working conditions*. (Doctoral dissertation). Boston, MA: Boston College.
- Carroll, S., Reichardt, R., Guarino, C., & Mejia, A. (2000). *The distribution of teachers among California's school districts and schools*. Santa Monica, CA: Rand Corporation.
- *Chapman, D. W., & Huteson, S. M. (1982). Attrition from teaching careers: A discriminant analysis. *American Educational Research Journal*, 19(1), 93–105.
- *Clewell, B. C., & Villegas, A. M. (2001). *Evaluation of the DeWitt Wallace-Reader's Digest Fund's pathways to teaching careers program*. Washington, DC: Urban Institute.
- *Clotfelter, C., Glennie, E., Ladd, H., & Vigdor, J. (2008). Would higher salaries keep teachers in high-poverty schools? Evidence from a policy intervention in North Carolina. *Journal of Public Economics*, 92(5), 1352–1370.
- *Clotfelter, C. T., Ladd, H. F., & Vigdor, J. L. (2011). Teacher mobility, school segregation, and pay-based policies to level the playing field. *Education*, 6(3), 399–438.
- Coburn, C. E., & Penuel, W. R. (2016). Research–practice partnerships in education outcomes, dynamics, and open questions. *Educational Researcher*, 45(1), 48–54.
- Cohen-Vogel, L., Cannata, M., Rutledge, S. A., & Socol, A. R. (2016). A model of continuous improvement in high schools: A process for research, innovation design, implementation, and scale. *Teachers College Record*, 118(13), n13.
- *Connelly, V., & Graham, S. (2009). Student teaching and teacher attrition in special education. *Teacher Education and Special Education*, 32(3), 257–269.
- Corcoran, S. P., Evans, W. N., & Schwab, R. M. (2004). Changing labor-market opportunities for women and the quality of teachers, 1957–2000. *American Economic Review*, 94(2), 230–235.
- Cotton, J. L., & Tuttle, J. M. (1986). Employee turnover: A meta-analysis and review with implications for research. *Academy of Management Review*, 11(1), 55–70.

- *Cowan, J., & Goldhaber, D. (2015). *Do bonuses affect teacher staffing and student achievement in high-poverty schools? Evidence from an incentive for National Board certified teachers in Washington State*. Seattle, WA: Center for Education Data & Research.
- *Cowen, J. M., Butler, J. S., Fowles, J., Streams, M. E., & Toma, E. F. (2012). Teacher retention in Appalachian schools: Evidence from Kentucky. *Economics of Education Review*, 31(4), 431–441.
- *Crown, K. M. (2009). *Do interactions between mentors and mentees decrease levels of new teacher attrition?* (Doctoral dissertation). Prescott Valley, AZ: Northcentral University.
- Cullen, J. B., Koedel, C., & Parsons, E. (2016). The compositional effect of rigorous teacher evaluation on workforce quality. *NBER No. 22805*.
- *Dagli, U. Y. (2012). America's public school kindergarten teachers' job turnover and associated factors. *Educational Sciences: Theory and Practice*, 12(4), 3121–3134.
- *Dahlkamp, S., Peters, M. L., & Schumacher, G. (2017). Principal Self-Efficacy, School Climate, and Teacher Retention: A Multi-Level Analysis. *Alberta Journal of Educational Research*, 63(4), 357–376.
- Darling-Hammond, L. (2013). *Getting teacher evaluation right: What really matters for effectiveness and improvement*. New York, NY: Teachers College Press.
- Darling-Hammond, L., Amrein-Beardsley, A., Haertel, E., & Rothstein, J. (2012). Evaluating teacher evaluation. *Phi Delta Kappan*, 93(6), 8–15.
- Datnow, A., & Castellano, M. E. (2001). Managing and guiding school reform: Leadership in success for all schools. *Educational Administration Quarterly*, 37(2), 219–249.
- *De Jong, D., & Campoli, A. (2018). Curricular coaches' impact on retention for early-career elementary teachers in the USA: Implications for urban schools. *International Journal of Mentoring and Coaching in Education*, 7(2), 191–200.
- *Dee, T. S., & Wyckoff, J. (2015). Incentives, selection, and teacher performance: Evidence from IMPACT. *Journal of Policy Analysis and Management*, 34(2), 267–297.
- DeFeo, D. J., Tran, T., Hirshberg, D., Cope, D., & Cravez, P. (2017). *The cost of teacher turnover in Alaska*. Anchorage, AK: Center for Alaska Education Policy Research.
- *Djonko-Moore, C. M. (2016). An exploration of teacher attrition and mobility in high poverty racially segregated schools. *Race Ethnicity and Education*, 19(5), 1063–1087.
- *Dolton, P., & Van der Klaauw, W. (1999). The turnover of teachers: A competing risks explanation. *The Review of Economics and Statistics*, 81(3), 543–550.
- *Donaldson, M. L. (2012). The promise of older novices: Teach for America teachers' age of entry and subsequent retention in teaching and schools. *Teachers College Record*, 114(10), n10.
- *Donaldson, M. L., & Johnson, S. M. (2010). The price of misassignment: The role of teaching assignments in Teach for America teachers' exit from low-income schools and the teaching profession. *Educational Evaluation and Policy Analysis*, 32(2), 299–323.
- *Dupriez, V., Delvaux, B., & Lothaire, S. (2016). Teacher shortage and attrition: Why do they leave? *British Educational Research Journal*, 42(1), 21–39.
- Dworkin, A. G. (1980). The changing demography of public school teachers: Some implications for faculty turnover in urban areas. *Sociology of Education*, 53(2), 65–73.
- *Elfers, A. M., Plecki, M. L., & Van Windekens, A. (2017). *Understanding Teacher Retention and Mobility in Washington State*. University of Washington.

- Eller, W., Doerfler, C., & Meier, K. (2000). *Teacher turnover in Texas: Problems and prospects. A report of the Texas Educational Excellence Project*. College Station: Texas A&M University.
- Engel, M., & Cannata, M. (2015). Localism and teacher labor markets: How geography and decision making may contribute to inequality. *Peabody Journal of Education*, 90(1), 84-92.
- Engel, M., Jacob, B. A., & Curran, F. C. (2014). New evidence on teacher labor supply. *American Educational Research Journal*, 51(1), 36-72.
- *Erickson, S. J. (2007). *An examination of the relationship between professional development and teacher turnover*. (Doctoral dissertation). Eugene, OR: University of Oregon.
- Fairchild, S., Tobias, R., Corcoran, S., Djukic, M., Kovner, C., & Noguera, P. (2012). White and black teachers' job satisfaction: Does relational demography matter? *Urban Education*, 47(1), 170-197.
- *Falch, T., & Rønning, M. (2007). The influence of student achievement on teacher turnover. *Education Economics*, 15(2), 177-202.
- *Falch, T., & Strøm, B. (2005). Teacher turnover and non-pecuniary factors. *Economics of Education Review*, 24(6), 611-631.
- *Feng, L. (2009). Opportunity wages, classroom characteristics, and teacher mobility. *Southern Economic Journal*, 75(4), 1165-1190.
- *Feng, L. (2010). Hire today, gone tomorrow: New teacher classroom assignments and teacher mobility. *Education*, 5(3), 278-316.
- *Feng, L., Figlio, D. N., & Sass, T. (2010). School accountability and teacher mobility. *National Bureau of Economic Research Working Paper No. 16070*.
- *Feng, L., & Sass, T. (2015). The impact of incentives to recruit and retain teachers in "hard-to-staff" subjects: An analysis of the Florida critical teacher shortage program. *National Center for Analysis of Longitudinal Data in Education Research Working Paper No. 141*.
- *Feng, L., & Sass, T. R. (2017a). Teacher quality and teacher mobility. *Education Finance and Policy*, 12(3), 396-418.
- *Feng, L., & Sass, T. R. (2017b). The impact of incentives to recruit and retain teachers in "hard-to-staff" subjects. *Journal of Policy Analysis and Management*.
- *Fryer, R. G. (2013). Teacher incentives and student achievement: Evidence from New York City public schools. *Journal of Labor Economics*, 31(2), 373-407.
- *Fulbeck, E. S. (2014). Teacher mobility and financial incentives: A descriptive analysis of Denver's ProComp. *Educational Evaluation and Policy Analysis*, 36(1), 67-82.
- *Gilmour, A. F. (2017). *Examining the inclusion of students with disabilities and teacher attrition* (Doctoral dissertation). Vanderbilt University. Nashville, TN.
- *Glazerman, S., Protik, A., Teh, B., Bruch, J., & Max, J. (2013). *Transfer incentives for high-performing teachers: Final results from a multisite randomized experiment*. Washington, DC: National Center for Education Evaluation and Regional Assistance.
- *Glazerman, S., & Seifullah, A. (2012). *An evaluation of the Chicago Teacher Advancement Program (Chicago TAP) after four years*. Princeton, NJ: Mathematica Policy Research.
- *Goldhaber, D., Gross, B., & Player, D. (2011). Teacher career paths, teacher quality, and persistence in the classroom: Are public schools keeping their best? *Journal of Policy Analysis and Management*, 30(1), 57-87.

- *Goldhaber, D., & Hansen, M. (2009). National Board certification and teachers' career paths: Does NBPTS certification influence how long teachers remain in the profession and where they teach? *Education*, 4(3), 229–262.
- Goldhaber, D., Hansen, M., & Walch, J. (2016). Time to Tenure: Does Tenure Reform Affect Teacher Absence Behavior and Mobility? *National Center for Analysis of Longitudinal Data in Education Research Working Paper No. 172*.
- *Goldhaber, D., Krieg, J. M., & Theobald, R. (2016). Does the match matter? Exploring whether student teaching experiences affect teacher effectiveness and attrition. *National Center for Analysis of Longitudinal Data in Education Research Working Paper No. 149*.
- *Goldhaber, D., Lavery, L., & Theobald, R. (2016). Inconvenient truth? Do collective bargaining agreements help explain the mobility of teachers within school districts? *Journal of Policy Analysis and Management*, 35(4), 848–880.
- Griffeth, R. W., Hom, P. W., & Gaertner, S. (2000). A meta-analysis of antecedents and correlates of employee turnover: Update, moderator tests, and research implications for the next millennium. *Journal of Management*, 26(3), 463–488.
- *Grissmer, D. W., & Kirby, S. N. (1992). *Patterns of attrition among Indiana teachers: 1965–1987*. Santa Monica, CA: Rand Corporation.
- Grissom, J. A. (2011). Can good principals keep teachers in disadvantaged schools? Linking principal effectiveness to teacher satisfaction and turnover in hard-to-staff environments. *Teachers College Record*, 113(11), 2552–2585.
- Grissom, J.A., & Bartanen, B. (2017) Strategic retention: New evidence on principal effectiveness and teacher turnover. Working paper.
- Grissom, J. A., & Keiser, L. R. (2011). A supervisor like me: Race, representation, and the satisfaction and turnover decisions of public sector employees. *Journal of Policy Analysis and Management*, 30(3), 557–580.
- Grissom, J. A., Kern, E. C., & Rodriguez, L. A. (2015). The “representative bureaucracy” in education: Educator workforce diversity, policy outputs, and outcomes for disadvantaged students. *Educational Researcher*, 44(3), 185–192.
- Grissom, J. A., Nicholson-Crotty, J., & Keiser, L. (2012). Does my boss's gender matter? Explaining job satisfaction and employee turnover in the public sector. *Journal of Public Administration Research and Theory*, 22(4), 649–673.
- Grissom, J. A., Nicholson-Crotty, J., & Nicholson-Crotty, S. (2009). Race, region, and representative bureaucracy. *Public Administration Review*, 69(5), 911–919.
- Grissom, J. A., Viano, S. L., & Selin, J. L. (2016). Understanding employee turnover in the public sector: Insights from research on teacher mobility. *Public Administration Review*, 76(2), 241–251.
- *Gritz, R. M., & Theobald, N. D. (1996). The effects of school district spending priorities on length of stay in teaching. *Journal of Human Resources*, 477–512.
- Guarino, C. M., Santibanez, L., & Daley, G. A. (2006). Teacher recruitment and retention: A review of the recent empirical literature. *Review of Educational Research*, 76(2), 173–208.
- *Hahs-Vaughn, D. L., & Scherff, L. (2008). Beginning English teacher attrition, mobility, and retention. *The Journal of Experimental Education*, 77(1), 21–54.
- Hall, B. W., Pearson, L. C., & Carroll, D. (1992). Teachers' long-range teaching plans: A discriminant analysis. *Journal of Educational Research*, 85(4), 221–225.

- *Hanushek, E. A., Kain, J. F., & Rivkin, S. G. (2004). Why public schools lose teachers. *Journal of Human Resources*, 39(2), 326–354.
- *Harrell, P., Leavell, A., van Tassel, F., & McKee, K. (2004). No teacher left behind: Results of a five-year study of teacher attrition. *Action in Teacher Education*, 26(2), 47–59.
- *Harris, D. C. (2007). Should I stay or should I go? Comparing teacher mobility in Florida's charter and traditional public schools. *Peabody Journal of Education*, 82(2–3), 274–310.
- *Harris-McIntyre, D. F. (2013). The impact of teacher induction programs on the retention of novice teachers. (Doctoral dissertation). Lauderdale, FL: Keiser University.
- Hedges, L. V., Tipton, E., & Johnson, M. C. (2010). Robust variance estimation in meta-regression with dependent effect size estimates. *Research synthesis methods*, 1(1), 39–65.
- Heissel, J. A., & Ladd, H. F. (2018). School turnaround in North Carolina: A regression discontinuity analysis. *Economics of Education Review*, 62, 302–320.
- *Helms-Lorenz, M., van de Grift, W., & Maulana, R. (2016). Longitudinal effects of induction on teaching skills and attrition rates of beginning teachers. *School Effectiveness and School Improvement*, 27(2), 178–204.
- *Henke, R. R., Chen, X., Geis, S., & Knepper, P. (2000). *Progress through the teacher pipeline: 1992-93 college graduates and elementary/secondary teaching as of 1997* (NCES 2000-152). Washington, DC: National Center for Education Statistics.
- *Hildebrand, T. N. (2018). The Relationship between Teacher Retention and Original Career Goals, Teacher Efficacy and Empathy: A Study of Teach For America Alumni. (Doctoral dissertation). Marquette University. Milwaukee, Wisconsin.
- Hill, D. M., & Barth, M. (2004). NCLB and teacher retention: Who will turn out the lights? *Education and the Law*, 16(2–3), 173–181.
- *Hough, H. J. (2012). *Salary incentives and teacher quality: The effect of a district-level salary increase on teacher retention*. Palo Alto, CA: Center for Education Policy Analysis.
- Horng, E. L. (2009). Teacher tradeoffs: Disentangling teachers' preferences for working conditions and student demographics. *American Educational Research Journal*, 46(3), 690–717.
- Hoxby, C. M., & Leigh, A. (2004). Pulled away or pushed out? Explaining the decline of teacher aptitude in the United States. *The American Economic Review*, 94(2), 236–240.
- *Imazeki, J. (2005). Teacher salaries and teacher attrition. *Economics of Education Review*, 24(4), 431–449.
- *Ingersoll, R. M. (2001). Teacher turnover and teacher shortages: An organizational analysis. *American Educational Research Journal*, 38(3), 499–534.
- Ingersoll, R. M., & Alsalam, N. (1997). *Teacher professionalization and teacher commitment: A multilevel analysis* (NCES 97-069). Washington, DC: National Center for Education Statistics.
- *Ingersoll, R. M., & May, H. (2012). The magnitude, destinations, and determinants of mathematics and science teacher turnover. *Educational Evaluation and Policy Analysis*, 34(4), 435–464.
- *Ingle, W. (2009). Teacher quality and attrition in a US school district. *Journal of Educational Administration*, 47(5), 557–585.
- *Irizarry, J., & Donaldson, M. L. (2012). Teach for America: The Latinization of US schools and the critical shortage of Latina/o teachers. *American Educational Research Journal*, 49(1), 155–194.

- *Jackson, K. M. (2012). Influence matters: The link between principal and teacher influence over school policy and teacher turnover. *Journal of School Leadership*, 22(5), 875-901.
- Jacob, B. A. (2007). The challenges of staffing urban schools with effective teachers. *The Future of Children*, 17(1), 129-153.
- Johnson, S. M., Berg, J. H., & Donaldson, M. L. (2005). *Who stays in teaching and why?: A review of the literature on teacher retention*. Boston, MA, Harvard Graduate School of Education, Project on the Next Generation of Teachers.
- *Johnson, S. M., & Birkeland, S. E. (2003). Pursuing a “sense of success”: New teachers explain their career decisions. *American Educational Research Journal*, 40(3), 581-617.
- *Jones, N. D., Maier, A., & Grogan, E. (2011). The extent of late-hiring and its relationship with teacher turnover: Evidence from Michigan. Unpublished manuscript.
- *Jones, V. E. (2013). Teacher attrition and mentoring: An examination of teacher attrition and first year experiences: Implications for policy. (Doctoral dissertation). Tuscaloosa, AL: The University of Alabama.
- Keigher, A. (2010). *Teacher attrition and mobility: Results from the 2008-09 Teacher Follow-Up Survey*. Washington, DC: National Center for Education Statistics.
- *Kelly, S. (2004). An event history analysis of teacher attrition: Salary, teacher tracking, and socially disadvantaged schools. *The Journal of Experimental Education*, 72(3), 195-220.
- *Kelly, S., & Northrop, L. (2015). Early career outcomes for the “best and the brightest” selectivity, satisfaction, and attrition in the beginning teacher longitudinal survey. *American Educational Research Journal*, 52(4), 624-656.
- *Kirby, S. N., Berends, M., & Naftel, S. (1999). Supply and demand of minority teachers in Texas: Problems and prospects. *Educational Evaluation and Policy Analysis*, 21(1), 47-66.
- *Kraft, M. A., Marinell, W. H., & Yee, D. (2016). School organizational contexts, teacher turnover, and student achievement: Evidence from panel data. *American Educational Research Journal*, 53(5), 1411-1449.
- *Kukla-Acevedo, S. (2009). Leavers, movers, and stayers: The role of workplace conditions in teacher mobility decisions. *The Journal of Educational Research*, 102(6), 443-452.
- Lankford, H., Loeb, S., & Wyckoff, J. (2002). Teacher sorting and the plight of urban schools: A descriptive analysis. *Educational Evaluation and Policy Analysis*, 24(1), 37-62.
- Li, D. (2012). School Accountability and Principal Mobility: How No Child Left Behind Affects the Allocation of School Leaders. Working paper.
- Lipsey, M.W., & Wilson, D. B. (2001). *Practical meta-analysis* (Vol. 49). Thousand Oaks, CA: Sage publications.
- *Lochmiller, C. R., Sugimoto, T. J., & Muller, P. A. (2016). *Teacher retention, mobility, and attrition in Kentucky public schools from 2008 to 2012* (REL 2016-116). Washington, DC: U.S. Department of Education.
- *Loeb, S., Kalogrides, D., & Béteille, T. (2012). Effective schools: Teacher hiring, assignment, development, and retention. *Education*, 7(3), 269-304.
- *Luke, C. C. (2014). *The effect of state induction policies on novice teacher attrition*. Albany, NY: University of Albany.
- Macdonald, D. (1999). Teacher attrition: A review of literature. *Teaching and Teacher Education*, 15(8), 835-848.

- *Marso, R. N., & Pigge, F. L. (1997). A longitudinal study of persisting and nonpersisting teachers' academic and personal characteristics. *The Journal of Experimental Education*, 65(3), 243–254.
- *Mihaly, K., Master, B., & Yoon, C. (2015). *Examining the early impacts of the leading educators fellowship on student achievement and teacher retention*. Santa Monica, CA: Rand Corporation.
- Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., Group, P., & others. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med*, 6(7), e1000097.
- *Mont, D., & Rees, D. I. (1996). The influence of classroom characteristics on high school teacher turnover. *Economic Inquiry*, 34(1), 152–167.
- *Moore, C. M. (2011). Why do teachers quit? An investigation of the influence of school environment and teacher characteristics on discontent and attrition. (Doctoral dissertation). Philadelphia, PA: Temple University.
- Murnane, R. J., & Steele, J. L. (2007). What is the problem? The challenge of providing effective teachers for all children. *The Future of Children*, 17(1), 15–43.
- Murphy, J., Hallinger, P., & Heck, R. H. (2013). Leading via teacher evaluation: The case of the missing clothes? *Educational Researcher*, 42(6), 349–354.
- *Nah, E. (2015). Factors affecting the retention of effective teachers. (Doctoral dissertation). Claremont, CA: Claremont Graduate University.
- *Newton, X. A., Rivero, R., Fuller, B., & Dauter, L. (2011). Teacher stability and turnover in Los Angeles: The influence of teacher and school characteristics. *Policy Analysis for California Education Working Paper*.
- *Newton, X. A., Rivero, R., Fuller, B., & Dauter, L. (2018). Teacher Turnover in Organizational Context: Staffing Stability in Los Angeles Charter, Magnet, and Regular Public Schools. *Teachers College Record*, 120(3), n3.
- Nguyen, T.D., Grissom, J., & Patrick, S.K. (2017) Not Just Black and White: The Effects of Demographic Incongruence on Teacher Turnover in a Multiethnic School System. Working paper.
- Nguyen, T.D. & Hunter, S. (2018) Towards an Understanding of Dynamics among Teachers, Teacher Leaders, and Administrators in a Teacher-led School Reform. *Journal of Educational Change*, 19(4), 539-565.
- *Ogundimu, C. O. (2014). Does the mode of entry into teaching matter in teacher retention? A discrete-time survival analysis modeling of New York City public school teachers. (Doctoral dissertation). New York, NY: Columbia University.
- *Ondrich, J., Pas, E., & Yinger, J. (2008). The determinants of teacher attrition in upstate New York. *Public Finance Review*, 36(1), 112-144.
- *Perda, D. (2013). Transitions into and out of teaching: A longitudinal analysis of early career teacher turnover. (Doctoral dissertation). Philadelphia, PA: University of Pennsylvania.
- Peterson, K. D. (2000). *Teacher evaluation: A comprehensive guide to new directions and practices*. Thousand Oaks, CA: Corwin Press.
- Pham, L.D., Nguyen, T.D., & Springer, M.G. (2017) Teacher Merit Pay and Student Test Scores: A Meta-Analysis. Working paper.
- *Player, D., Youngs, P., Perrone, F., & Grogan, E. (2017). How principal leadership and person-job fit are associated with teacher mobility and attrition. *Teaching and Teacher Education*, 67, 330-339.

- Podgursky, M., Monroe, R., & Watson, D. (2004). The academic quality of public school teachers: An analysis of entry and exit behavior. *Economics of Education Review*, 23(5), 507-518.
- *Prost, C. (2013). Teacher mobility: can financial incentives help disadvantaged schools to retain their teachers? *Annals of Economics and Statistics*, (111-112), 171-191.
- *Redding, C., & Smith, T. M. (2016). Easy in, easy out: Are alternatively certified teachers turning over at increased rates? *American Educational Research Journal*, 53(4), 1086–1125.
- *Rees, D. I. (1991). Grievance procedure strength and teacher quits. *ILR Review*, 45(1), 31-43.
- *Renzulli, L. A., Parrott, H. M., & Beattie, I. R. (2011). Racial mismatch and school type teacher satisfaction and retention in charter and traditional public schools. *Sociology of Education*, 84(1), 23–48.
- *Rickman, B. D., & Parker, C. D. (1990). Alternative wages and teacher mobility: A human capital approach. *Economics of Education Review*, 9(1), 73-79.
- Rockoff, J. E. (2004). The impact of individual teachers on student achievement: Evidence from panel data. *The American Economic Review*, 94(2), 247–252.
- *Ronfeldt, M. (2012). Where should student teachers learn to teach? Effects of field placement school characteristics on teacher retention and effectiveness. *Educational Evaluation and Policy Analysis*, 34(1), 3-26.
- Ronfeldt, M., Loeb, S., & Wyckoff, J. (2013). How teacher turnover harms student achievement. *American Educational Research Journal*, 50(1), 4–36.
- * Ronfeldt, M., & McQueen, K. (2017). Does new teacher induction really improve retention?. *Journal of Teacher Education*, 68(4), 394-410.
- Rubenstein, A. L., Eberly, M. B., Lee, T. W., & Mitchell, T. R. (2017). Surveying the forest: A meta-analysis, moderator investigation, and future-oriented discussion of the antecedents of voluntary employee turnover. *Personnel Psychology*, 00, 1-43.
- *Sass, D. A., Bustos Flores, B., Claeys, L., & Pérez, B. (2012). Identifying personal and contextual factors that contribute to attrition rates for Texas public school teachers. *Education Policy Analysis Archives*, 20(15), 1-30.
- *Scafidi, B., Sjoquist, D. L., & Stinebrickner, T. R. (2007). Race, poverty, and teacher mobility. *Economics of Education Review*, 26(2), 145-159.
- *Schlechty, P. C., & Vance, V. S. (1981). Do academically able teachers leave education? The North Carolina case. *The Phi Delta Kappan*, 63(2), 106-112.
- Shaw, T. B. (2016). How does participating in a teacher leadership program impact secondary teachers' retention, instructional capacity, and influence on other teachers? (Doctoral dissertation). Memphis, TN: University of Memphis.
- Shen, J. (1997). Teacher retention and attrition in public schools: Evidence from SASS91. *Journal of Educational Research*, 91(2), 81–88.
- Shiffrin, R.M (2016). Drawing Causal Inference from Big Data, Proceedings of the National Academy of Sciences, 113(27), 7308-7309 or something like Einav and Levin (2014). Economics in the Age of Big Data. *Science*, 346(6210).
- *Shin, H. (1995). Estimating future teacher supply: Any policy implications for educational reform. *International Journal of Educational Reform*, 4(4), 422-433.
- Shirrell, M. (2016). The effects of subgroup-specific accountability on teacher turnover and attrition. *Education Finance and Policy*, 0(ja), 1-60.

- Simon, N. S., & Johnson, S. M. (2015). Teacher turnover in high-poverty schools: What we know and can do. *Teachers College Record*, 117(3), 1-36.
- *Smith, T. M. (2006). How do state-level induction and standards-based reform policies affect induction experiences and turnover among new teachers?. *American Journal of Education*, 113(2), 273-309.
- *Smith, T. M., & Ingersoll, R. M. (2004). What are the effects of induction and mentoring on beginning teacher turnover? *American Educational Research Journal*, 41(3), 681-714.
- *Sohn, K. (2009). Teacher turnover: An issue of workgroup racial diversity. *Education Policy Analysis Archives*, 17(11), 1-26.
- Springer, M. G., Ballou, D., & Peng, A. X. (2014). Estimated effect of the teacher advancement program on student test score gains. *Education Finance and Policy*, 9(2), 193-230.
- *Springer, M. G., Lewis, J. L., Podgursky, M. J., Ehlert, M. W., Taylor, L. L., Lopez, O. S., & Peng, A. (2009). *Governor's Educator Excellence Grant (GEEG) Program: Year Three Evaluation Report*. Nashville, TN: National Center on Performance Incentives.
- *Springer, M. G., Podgursky, M. J., Lewis, J. L., Ehlert, M. W., Gronberg, T. J., Hamilton, L. S., ... & Taylor, L. L. (2008). *Texas Educator Excellence Grant (TEEG) Program: Year Two Evaluation Report*. Nashville, TN: National Center on Performance Incentives.
- *Springer, M. G., Lewis, J. L., Ehlert, M. W., Podgursky, M. J., Crader, G. D., Taylor, L. L., & Stuit, D. A. (2010). *District awards for teacher excellence (DATE) Program: Final Evaluation Report*. Nashville, TN: National Center on Performance Incentives.
- *Steele, J. L., Murnane, R. J., & Willett, J. B. (2010). Do financial incentives help low-performing schools attract and keep academically talented teachers? Evidence from California. *Journal of Policy Analysis and Management*, 29(3), 451-478.
- *Steele, J. L., Pepper, M. J., Springer, M. G., & Lockwood, J. R. (2015). The distribution and mobility of effective teachers: Evidence from a large, urban school district. *Economics of Education Review*, 48, 86-101.
- *Stinebrickner, T. R. (1998). An empirical investigation of teacher attrition. *Economics of Education Review*, 17(2), 127-136.
- *Stinebrickner, T. R. (1999). Estimation of a duration model in the presence of missing data. *Review of Economics and Statistics*, 81(3), 529-542.
- *Stinebrickner, T. R. (2002). An analysis of occupational change and departure from the labor force: Evidence of the reasons that teachers leave. *Journal of Human Resources*, 192-216.
- Stockard, J., & Lehman, M. B. (2004). Influences on the satisfaction and retention of 1st-year teachers: The importance of effective school management. *Educational Administration Quarterly*, 40(5), 742-771.
- Stuit, D. A., & Smith, T. M. (2012). Explaining the gap in charter and traditional public school teacher turnover rates. *Economics of Education Review*, 31(2), 268-279.
- Sun, M., Penner, E. K., & Loeb, S. (2017). Resource-and approach-driven multidimensional change: Three-year effects of School Improvement Grants. *American Educational Research Journal*, 54(4), 607-643.
- *Sun, M., Saultz, A., & Ye, Y. (2017). Federal policy and the teacher labor market: exploring the effects of NCLB school accountability on teacher turnover. *School Effectiveness and School Improvement*, 28(1), 102-122.

- Tanner-Smith, E. E., & Tipton, E. (2014). Robust variance estimation with dependent effect sizes: practical considerations including a software tutorial in Stata and SPSS. *Research Synthesis Methods*, 5(1), 13-30.
- *Texas Education Agency. (1995) *Texas teacher retention, mobility, and attrition. Teacher supply, demand, and quality policy research project. Report Number 6*. Austin, TX: Texas Education Agency, Publications Distribution Division.
- *Urlick, A. (2016). The influence of typologies of school leaders on teacher retention: A multilevel latent class analysis. *Journal of Educational Administration*, 54(4), 434-468.
- *Vagi, R., Pivovarova, M., & Miedel Barnard, W. (2017). Keeping Our Best? A Survival Analysis Examining a Measure of Preservice Teacher Quality and Teacher Attrition. *Journal of Teacher Education*,
- Weiss, E. M. (1999). Perceived workplace conditions and first-year teachers' morale, career choice commitment, and planned retention: A secondary analysis. *Teaching and Teacher Education*, 15(8), 861-879.
- *Wells, M. B. (2015). Predicting preschool teacher retention and turnover in newly hired Head Start teachers across the first half of the school year. *Early Childhood Research Quarterly*, 30(1), 152-159.
- Whitener, S. D., Gruber, K. J., Lynch, H., Tingos, K., Perona, M., & Fondelier, S. (1997). *Characteristics of stayers, movers, and leavers: Results from the Teacher Followup Survey: 1994-95* (NCES 97-450). Washington, DC: National Center for Education Statistics.
- Wilson, S. M., Floden, R. E., & Ferrini-Mundy, J. (2001). *Teacher preparation research: Current knowledge, gaps, and recommendations*. Seattle, WA: University of Washington, Center for the Study of Teaching and Policy.
- *Zhang, G., & Zeller, N. (2016). A longitudinal investigation of the relationship between teacher preparation and teacher retention. *Teacher Education Quarterly*, 43(2), 73-92.
- * denotes primary studies used in meta-analysis

Tables

Table 1

Descriptive information on the primary studies by study characteristics

	Included in prior reviews	New studies
<i>Study characteristics</i>		
Peer Review	85%	62%
Median Sample Size	2690	9150
“Big Data”	8%	19%
Quasi-exp/experimental	4%	33%
Median Study Quality	2	4
Mean Study Quality	2.69	3.45
Number of studies	26	94

Note. “Big Data” studies are studies using longitudinal data of at least three continuous years and having sample sizes larger than 100,000 observations, the median number of observations in the full sample. Quasi-experimental/experimental studies are studies that provide at least one plausibly causal estimate on a determinant of teacher attrition and retention. Study quality is ranked from 1-5 on a subjective ranking scale where 1 is high risk of bias and 5 is low risk of bias.

Table 2

Personal correlates as determinants of teacher attrition and retention (Odds Ratio only)

Factor	# of studies	Main effect estimates					
		Odds ratio	Logged odds ratio	SE	Lower bound	Upper bound	p
Panel A: Teacher Characteristics							
Age (continuous)	10	0.948	-0.054	0.030	-0.113	0.005	0.072
Age (> 28)	9	0.698	-0.359	0.189	-0.729	0.011	0.057
Male	37	1.023	0.023	0.036	-0.047	0.093	0.523
Minority (Black)	14	1.080	0.077	0.320	-0.551	0.704	0.811
Minority (Hisp.)	11	0.473	-0.749	0.176	-1.095	-0.404	0.000
Minority (non-white)	12	0.842	-0.172	0.087	-0.342	-0.002	0.048
Married	4	1.091	0.087	0.050	-0.012	0.186	0.084
Number of children	1~	0.379	-0.971	0.294	-1.548	-0.394	0.001
Young child	2	0.561	-0.578	0.154	-0.880	-0.275	0.000
Career satisfaction	7	0.847	-0.167	0.056	-0.276	-0.057	0.003
Full time teaching	7	0.616	-0.485	0.123	-0.725	-0.244	0.000
Distance to school	1~	1.014	0.014	0.004	0.006	0.022	0.000
Panel B: Teacher Qualifications							
Ability (test scores)	5	1.118	0.112	0.069	-0.024	0.247	0.105
School selectivity	5	1.108	0.103	0.130	-0.152	0.358	0.429
Grad. (PhD v none)	17	1.047	0.046	0.094	-0.138	0.230	0.623
Grad. (MA/PhD v BA)	4	0.929	-0.073	0.151	-0.369	0.222	0.627
National Board	1	0.548	-0.602	0.453	-1.489	0.286	0.184
Teaching Fellow/TFA	2	1.017	0.017	1.009	-1.960	1.994	0.987
Highly qual. (NCLB)	2	0.932	-0.070	0.354	-0.763	0.623	0.843
Internship	1~	0.459	-0.779	0.395	-1.553	-0.006	0.048
Standard certification	16	0.526	-0.643	0.227	-1.087	-0.199	0.005
Specialty (STEM)	12	1.087	0.083	0.052	-0.019	0.185	0.111
Specialty (Special ed)	6	1.099	0.094	0.061	-0.025	0.214	0.121
Specialty (other)	2	1.353	0.302	0.463	-0.606	1.210	0.514
Experience (cont.)	10	0.996	-0.004	0.017	-0.037	0.030	0.834
Experience (<3)	13	1.542	0.433	0.097	0.243	0.623	0.000

Note. Assumed correlations between multiple, within-study outcomes is 0.5. ~Single study estimate, not meta-analytic results.

Table 3

School correlates as determinants of teacher attrition and retention (Odds Ratio only)

Factor	# of studies	Main effect estimates					p
		Odds ratio	Logged odds ratio	SE	Lower bound	Upper bound	
Panel A: School Organizational Characteristics							
School size	10	1.001	0.001	0.002	-0.003	0.004	0.792
Urban	9	1.059	0.058	0.090	-0.118	0.233	0.521
High school v. elem	4	1.312	0.272	0.199	-0.119	0.662	0.172
Middle school v. elem	4	1.505	0.409	0.144	0.126	0.691	0.005
Secondary v. elem	7	1.462	0.380	0.165	0.057	0.702	0.021
Charter v. trad public	2	1.983	0.685	0.167	0.358	1.011	0.000
Private v. trad public	2	1.584	0.460	0.428	-0.380	1.299	0.283
Student discip. problem	4	1.186	0.170	0.105	-0.035	0.375	0.103
Better work environ.	5	0.557	-0.585	0.271	-1.116	-0.054	0.031
Administrative support	13	0.796	-0.229	0.061	-0.348	-0.110	0.000
Teacher collaborations	5	0.888	-0.119	0.090	-0.295	0.057	0.186
Teacher leadership	4	1.022	0.022	0.099	-0.172	0.216	0.824
Professional develop.	3	0.838	-0.176	0.077	-0.327	-0.026	0.022
Induction/mentoring	11	0.767	-0.265	0.051	-0.365	-0.166	0.000
Classroom autonomy	5	0.959	-0.041	0.078	-0.194	0.111	0.594
Panel B: School Resources							
Class size	6	1.018	0.018	0.013	-0.008	0.043	0.184
Classroom assistant	2	0.933	-0.069	0.104	-0.273	0.134	0.504
Teaching materials	2	0.845	-0.168	0.062	-0.290	-0.046	0.007
Panel C: Student Body Characteristics							
Student achievement	10	0.901	-0.105	0.020	-0.144	-0.065	0.000
Percent Black	6	1.004	0.004	0.003	-0.002	0.010	0.161
Percent Hispanic	4	1.005	0.005	0.005	-0.004	0.015	0.290
Percent Minority	13	0.946	-0.056	0.021	-0.096	-0.015	0.007
Percent FRPL	13	1.006	0.006	0.004	-0.002	0.013	0.153
Poverty	4	1.019	0.019	0.072	-0.122	0.161	0.791
Percent IEP/LEP	5	0.999	-0.001	0.009	-0.019	0.018	0.945
Panel D: Relational Demography							
Race/gender congruence	2	0.545	-0.607	0.786	-2.147	0.933	0.440

Note. Assumed correlations between multiple, within-study outcomes is 0.5. ~Single study estimate, not meta-analytic results.

Table 4

External correlates as determinants of teacher attrition and retention (Odds Ratio only)

External correlates as determinants of teacher attrition and retention (Odds Ratio only)							
Factor	# of studies	Main effect estimates					
		Odds ratio	Logged odds ratio	SE	Lower bound	Upper bound	p
Panel A: Accountability							
Teacher evaluation	5	0.947	-0.054	0.027	-0.106	-0.002	0.041
Teacher eff. score	7	0.964	-0.037	0.021	-0.078	0.004	0.079
Principal eff. score	3	0.710	-0.342	0.108	-0.553	-0.131	0.001
Merit pay	3	0.784	-0.243	0.099	-0.436	-0.049	0.014
Merit pay (lin. prob.)	10	.	-0.016	0.007	-0.029	-0.003	0.016
Panel B: Workforce							
Employment rate	1~	0.969	-0.032	0.014	-0.059	-0.005	0.022
Late hiring	1~	1.781	0.577	0.124	0.334	0.820	0.000
Retention bonus	1~	0.990	-0.010	0.060	-0.128	0.108	0.868
Non-teacher salary	2	6.305	1.841	2.789	-3.625	7.307	0.509
Salary	18	0.977	-0.024	0.007	-0.038	-0.009	0.001
Union	3	0.745	-0.294	0.173	-0.634	0.046	0.090

Note. Assumed correlations between multiple, within-study outcomes is 0.5. ~Single study estimate, not meta-analytic results.

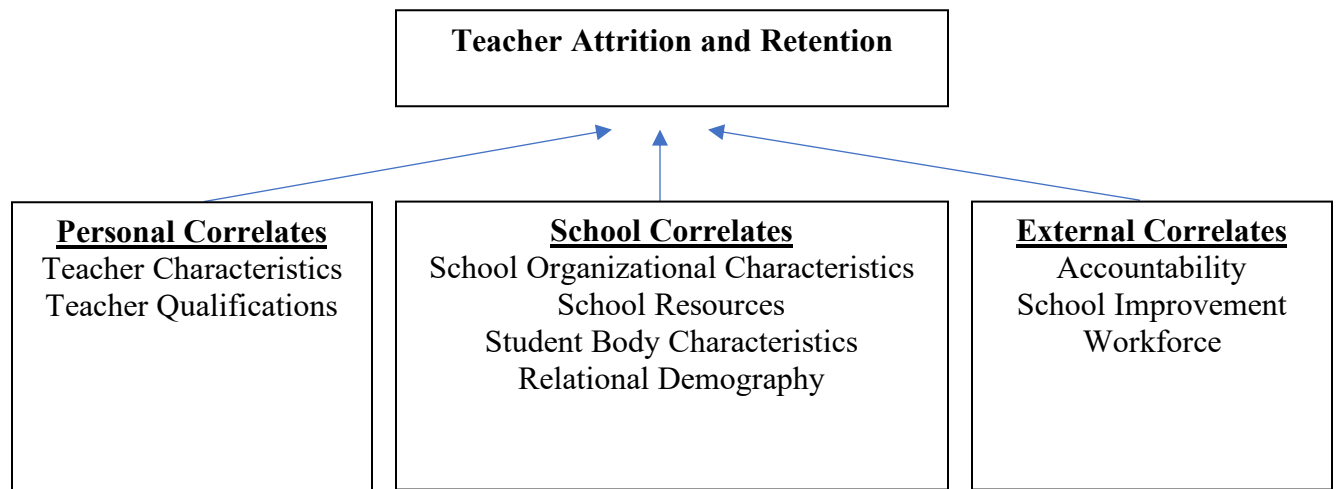
Figures

Figure 1. Conceptual Framework of Teacher Attrition and Retention

Technical Appendix

Forest Plot and Publication Bias

Since there are many determinants of teacher attrition, it would not be advisable to do forest plots and contoured enhanced funnel plots for all of them. We have opted to choose the determinant with the most number of primary studies to present the forest plot and contoured enhanced funnel plot. Appendix Figure 2, the forest plot of the effect sizes of gender and attrition, shows that most studies find gender does not greatly influence teacher attrition. There are a few studies that find male teachers are less likely to leave teaching than female teachers, but there are also studies that find the opposite. The overall meta-analytic log-odds result, as discussed previously, is around zero, indicating that gender is not an important determinant of teacher attrition.

The contoured enhanced funnel plot is used to examine the possibility of publication bias. The concern here is that if we observe asymmetry in positive and negative studies and their significance, which would suggest some particular type of bias. However, the funnel plot, Appendix Figure 3, shows no asymmetry since we observe both positive and negative findings and their significance levels are well represented in each cone. In other words, we find no evidence to suggest there is any publication bias for the studies that include gender as a determinant. Contoured enhanced funnel plots of other determinants suggest the same conclusion. Analyses of forest plots and funnel plots of other factors provide substantively similar conclusions (results available upon request).

Meta-regression Analyses

For ease of interpretation and presentation, meta-regression results for five moderators are compiled together in Appendix Table 9 and only the coefficients of interest, the slopes on the moderator variables, along with their significance levels are presented. A positive significant result

indicates that the odds of attrition increase for a unit increase in the measure of the moderator or when the moderator is “on” instead of “off.” It should be noted that since there are limited number of studies for many determinants, there is increased risk of the meta-regression analysis to be severely under-powered and the estimation is also at risk of driven by only a few studies (Bartolucci & Hillegass, 2010). As such, we have limited the meta-regression to determinants with at least eight studies and results with less than twenty studies should be interpreted cautiously. Among the determinants with twenty or more observations or studies for meta-regression analyses, all except one result is statistically insignificant with only the peer review indicator being marginally significant. This result indicates that, for peer-reviewed studies, the odds of attrition is decreased for teachers who are STEM teachers compared to non-specialty teachers. In other words, even though studies generally find that STEM teachers are more likely to leave teaching than non-specialty teachers, peer reviewed studies tend to find that the odds of attrition to be less pronounced than non-peer-reviewed studies.

For factors with less than twenty studies, the meta-regression results are generally not significant (likely underpowered) and there are no apparent patterns among the significant results except for the secondary versus elementary factor. The meta-regression results for this factor indicate that longitudinal studies, higher quality studies, and studies after 2005 generally find a decrease in the odds of attrition for secondary teaches relative to non-secondary teachers. In other words, studies using longitudinal data, higher quality studies, and more recent studies are more likely to find that secondary teachers are not more likely to leave teaching than elementary teachers. Overall, the results are mostly insignificant and there is little consistency in how these moderators influence the effects of the determinants.

Appendix Tables

Appendix Table 1

Categories and determinants of teacher attrition and retention

Personal correlates		School correlates				External correlates		
Teacher characteristics	Teacher qualifications	School org characteristics	School resources	Student body characteristics	Relational demography	Accountability	School improvement	Workforce
Age	Ability (test scores)	School size	Expenditure	Student achievement	Tch-princ race/gender match	Assessment impact	School reform	Employment rate
Gender	Education selectivity	Urbanicity	Class size	Percent minority	Tch-tch race match	Teacher effectiveness	Research-practice partnership	Late hiring
Race/ethnicity	Graduate Degree	Sec. vs elem. level	Classroom assistants	Poverty	Tch-student race match	Merit pay		Salary
Marital status	Certification	Private, public, charter	Teaching materials	Percent IEP/LEP		Federal policies (NCLB/ESSA)		Retention bonus
Children	Highly qualified (NCLB/ESSA)	Work environment				Principal effectiveness		Non-teacher salary
Satisfaction	Internship	Administrative support						Union
Full time Teaching	Specialty area (STEM, SPED)	Teacher collaborations						Tenure
Distance to school	Experience	Teacher leadership						Pension
	Prior non-teaching career experience	Professional development						
		Induction mentoring						
		Classroom autonomy						
		Stay ratio						

Note. The first five categories are adapted and expanded based on Borman & Dowling (2008). Stay ratio is the teacher retention rate at the school. Internship includes field placement. Teacher leadership includes teacher influence at the school level. Assessment impact includes evaluation used for school-level decision-making. In comparison, teacher effectiveness score is measured by a composite evaluation score or value-added score.

Appendix Table 2
Results by database

Database	Results
ERIC	5,667
WorldCat	4,909
NBER	4,270
ProQuest	4,634
DOAJ	3,491
JSTOR	1,111
Google scholar	1,000
Taylor and Francis online	689
Total	25,771

Search string: Teacher AND (attrition OR turnover OR retention OR leav* OR suppl* OR career OR attitudes OR mobility OR commit* OR persist*)

Google scholar limits the number of accessible articles to 1,000.

Appendix Table 3

Coding and descriptions of determinants

Determinant	Description
Teacher characteristics	
Age	Teacher's age express as continuous or less than 28/30 years old
Gender	Male vs. Female
Race/ethnicity	Black, Hispanic, non-White vs. White
Marital status	Married vs. non-married
Children	New child vs. no new child; number of kids
Satisfaction	Teacher's satisfaction with their job
Full time teaching	Full time vs. part time teaching
Distance to school	Distance from teacher's house to school
Teacher qualifications	
Ability (test scores)	Teacher's ability or achievement as measured by standardized tests and grades (SAT/ACT/rank quartile)
Education selectivity	The selectivity of undergraduate education
Graduate degree	Degree (MA/PhD) vs. non-graduate degree/BA
Certification	Certification (traditional/regular) vs. no cert.
Highly qualified	Designated as highly qualified by NCLB/ESSA
Internship	Participated in teaching internship or field placement prior to teaching
Specialty area	STEM/special ed vs. regular
Experience	Teaching experience (continuous measure); Less than 3 years of exp v. 3 or more years
Prior experience	Prior non-teaching career experience vs. none
School organizational characteristics	
School size	Large vs. small schools; school enrollment size
Urbanicity	Urban vs. rural schools
School level	Secondary vs. elementary; high school/middle schools vs. elementary schools
School sector	Charter/private vs. traditional public
Work environment	Facilities, teaching assignments; school problems; teacher victimization; student disciplinary problem
Administrative support	Measures of administrative support; teachers have regular supportive communication with administrators
Collaboration	Teacher collaboration; network of teachers
Leadership	Levels of teacher leadership or influence; teacher responsibility
Professional development	Measures of professional development; quality of professional development
Induction/Mentoring	Participation in induction/mentoring program
Classroom autonomy	Levels of classroom autonomy

Stay ratio	Teacher retention rate at the school
School resources	
Expenditure	Expenditure for support per teachers (in dollar amount)
Class size	Teacher's average class size
Classroom assistant	Has a teacher aid/assistant vs. none
Teaching materials	Has adequate teaching materials
Student body characteristics	
Student achievement	Measures of average student achievement
Percent minority students	School-level percent of Black, Hispanic, or minority
Poverty	Majority of school is in low socio-economic status; school-level percent of free and reduced price lunch
Percent IEP/LEP	School-level percent of individualized education program (IEP) or limited English proficiency (LEP)
Relational demography	
Teacher-principal race/gender matching	Race and gender matching between teacher and principal
Teacher-teacher race match	Race matching between the teacher and other teachers in the school
Teacher-student race matching	Race matching between students and teacher
Accountability	
Assessment impact	Effect of assessment impact, classroom observation and other evaluations
Teacher effectiveness score	Teacher effectiveness score from value-added measures; high vs. low teacher effectiveness
Merit pay	Impact of merit pay programs
Federal policies	Effects of federal policies such as NCLB or ESSA
Principal effectiveness score	Principal effectiveness from school-level value-added measures; other measures of principal effectiveness
School improvement	
School reform	Participation in some school reform such as Success for All
Research-practice partnership	Participation in a research-practice partnership
Workforce	
Employment rate	Overall employment rate in the state or district
Late hiring	Teachers hired late in the academic year
Teacher salary	Salary (in dollar amount); high vs. low
Retention bonus	Bonus given to teachers who stay in hard-to-staff schools or specialty subjects
Non-teacher salary	The salary of administrators and other opportunities
Union	Teacher has teacher union membership
Tenure	Effects of having tenure or tenure reform
Pension	Changes to pension plans

Appendix Table 4

*Study quality and risk of bias considerations***Quality Rating Considerations**

Did the study provide a clear review of prior research and motivate the study?

Were the research questions(s) clearly stated, and did the study answer the question(s)?

Was the dependent variable, teacher attrition or retention, clearly defined?

Were the independent variables clearly defined and appropriately operationalized?

Was the analytic approach adequately described, and what are the relative merits of the approach used?

Did the analytic approach adjust statistically for confounding variables? For qualitative studies, did the analysis consider and evaluate confirming and disaffirming evidence?

Were threats to internal and external validity considered and addressed?

Were findings robust to different analytical decisions and model specifications? For qualitative studies, were the findings generalizable to different contexts or circumstances within the study, or were the results idiosyncratic to some particular time and place?

What sampling decisions were made by the authors and did the analytic sample present any concerns to internal or external validity?

Appendix Table 5

Determinants of teacher attrition and retention including hazard ratios

Factor	# of studies	# of ES	Main effect estimates					
			Odds ratio	Logged odds ratio	SE	Lower bound	Upper bound	p
Panel A: Teacher Characteristics								
Age (continuous)	14	14	0.984	-0.016	0.008	-0.032	-0.001	0.038
Age (greater than 28)	14	14	0.707	-0.347	0.120	-0.583	-0.111	0.004
Male	51	51	0.993	-0.007	0.034	-0.072	0.059	0.846
Minority (Black)	23	23	0.949	-0.052	0.133	-0.313	0.209	0.697
Minority (Hispanic)	19	19	0.603	-0.505	0.095	-0.692	-0.319	<.001
Minority (non-white)	13	13	0.898	-0.108	0.087	-0.278	0.062	0.214
Married	7	7	1.164	0.152	0.099	-0.042	0.346	0.125
Number of children	4	4	0.501	-0.692	0.165	-1.015	-0.369	<.001
Young child	3	3	0.551	-0.596	0.153	-0.896	-0.296	<.001
Career satisfaction	7	7	0.847	-0.167	0.056	-0.276	-0.057	0.003
Full time teaching	7	7	0.616	-0.485	0.123	-0.725	-0.244	<.001
Distance to school	2	2	0.987	-0.013	0.033	-0.078	0.052	0.704
Panel B: Teacher Qualifications								
Ability (test scores)	9	9	1.089	0.085	0.040	0.007	0.164	0.033
School selectivity	8	8	1.094	0.090	0.040	0.012	0.168	0.024
Graduate (MA/PhD v none)	24	24	0.989	-0.011	0.064	-0.137	0.114	0.860
Graduate (MA/PhD v BA)	7	7	1.059	0.057	0.085	-0.110	0.225	0.502
National Board	3	3	0.879	-0.129	0.372	-0.859	0.600	0.728
Teaching Fellow/TFA	3	3	1.096	0.091	0.542	-0.972	1.154	0.866
Highly qualified (NCLB)	2	2	0.932	-0.070	0.354	-0.763	0.623	0.843
Internship	4	4	0.866	-0.143	0.091	-0.323	0.036	0.116
Standard certification	21	21	0.586	-0.534	0.155	-0.838	-0.231	0.001
Specialty (STEM)	27	27	1.112	0.106	0.030	0.047	0.165	<.001
Specialty (Special ed)	12	12	1.128	0.121	0.037	0.049	0.193	0.001
Specialty (other)	5	5	1.240	0.215	0.031	0.155	0.276	<.001
Experience (cont.)	13	13	1.002	0.002	0.013	-0.024	0.028	0.890
Experience (<3)	14	14	1.508	0.411	0.082	0.250	0.572	<.001

Panel C: School Organizational Characteristics

School size	13	13	1.001	0.001	0.001	-0.001	0.002	0.306
Urban v. rural	13	13	1.047	0.046	0.075	-0.101	0.193	0.540
High school v. elem	7	7	1.110	0.104	0.076	-0.045	0.254	0.171
Middle school v. elem	6	6	1.159	0.147	0.051	0.046	0.248	0.004
Secondary v. elem	14	14	1.143	0.134	0.061	0.013	0.254	0.030
Charter v. trad public	4	4	1.978	0.682	0.125	0.437	0.928	<.001
Private v. trad public	4	4	1.876	0.629	0.231	0.177	1.082	0.006
Student disciplinary problem	5	5	1.158	0.147	0.042	0.065	0.228	<.001
Better work environment	5	5	0.557	-0.585	0.271	-1.116	-0.054	0.031
Administrative support	13	13	0.796	-0.229	0.061	-0.348	-0.110	<.001
Teacher collaborations	5	5	0.888	-0.119	0.090	-0.295	0.057	0.186
Teacher leadership	4	4	1.022	0.022	0.099	-0.172	0.216	0.824
Professional development	3	3	0.838	-0.176	0.077	-0.327	-0.026	0.022
Induction/mentoring	11	11	0.767	-0.265	0.051	-0.365	-0.166	<.001
Classroom autonomy	5	5	0.959	-0.041	0.078	-0.194	0.111	0.594
Stay ratio	2	2	0.687	-0.375	0.308	-0.978	0.228	0.223
Panel D: School Resources								
Expend. support per teacher	2	2	0.934	-0.068	0.019	-0.104	-0.032	<.001
Class size	8	8	1.006	0.006	0.004	-0.001	0.014	0.112
Classroom assistant	3	3	0.899	-0.107	0.046	-0.197	-0.017	0.020
Teaching materials	2	2	0.845	-0.168	0.062	-0.290	-0.047	0.007
Panel E: Student Body Characteristics								
Student achievement	15	15	0.991	-0.009	0.004	-0.017	-0.001	0.025
Percent Black	9	9	1.005	0.005	0.004	-0.002	0.012	0.187
Percent Hispanic	8	8	1.010	0.009	0.006	-0.003	0.022	0.138
Percent Minority	15	15	0.995	-0.005	0.008	-0.020	0.010	0.516
Percent FRPL	17	17	1.006	0.006	0.004	-0.001	0.013	0.089
Poverty	8	8	1.052	0.051	0.049	-0.045	0.146	0.297
Percent IEP/LEP	6	6	0.997	-0.003	0.010	-0.023	0.017	0.769
Panel F: Relational Demography								
Race/gender congruence	3	3	0.873	-0.135	0.154	-0.438	0.167	0.380
Panel G: Accountability								
Teacher evaluation	5	5	0.947	-0.054	0.027	-0.106	-0.002	0.041

Teacher effectiveness score	8	8	0.941	-0.061	0.023	-0.106	-0.016	0.007
Principal effectiveness score	3	3	0.710	-0.342	0.108	-0.553	-0.131	0.001
Merit pay	3	3	0.784	-0.243	0.099	-0.436	-0.049	0.014
Merit pay (LPM)	10	10	.	-0.016	0.007	-0.029	-0.003	0.016
Panel H: Workforce								
Employment rate	2	2	0.994	-0.006	0.024	-0.053	0.041	0.799
Late hiring	1~	1	1.781	0.577	0.124	0.334	0.820	0.000
Retention bonus	3	3	0.915	-0.089	0.031	-0.150	-0.027	0.005
Non-teacher salary	4	4	0.796	-0.228	0.126	-0.475	0.019	0.071
Salary	30	30	0.980	-0.020	0.004	-0.027	-0.013	<.001
Union	3	3	0.745	-0.294	0.173	-0.634	0.046	0.090

Note. Estimates assume dependent effect sizes with within study correlation of 0.5. . ~Single study estimate, not meta-analytic results.

Determinants of teacher attrition and retention with robust variance estimation

Factor	# of studies	# of ES	Main effect estimates						
			Odds ratio	Logged odds ratio	SE	Lower bound	Upper bound	Adj df	p
Panel A: Teacher Characteristics									
Age (cont.)	14	16	0.982	-0.018	0.029	-0.069	0.034	11.753	0.549
Age (greater than 28)	14	33	0.711	-0.341	0.150	-0.606	-0.075	12.792	0.041
Male	51	59	0.993	-0.007	0.047	-0.087	0.073	39.510	0.888
Minority (Black)	23	29	0.948	-0.053	0.198	-0.394	0.288	20.030	0.791
Minority (Hispanic)	19	23	0.601	-0.509	0.266	-0.975	-0.044	15.787	0.074
Minority (non-white)	13	15	0.888	-0.118	0.118	-0.333	0.096	9.606	0.340
Married	7	8	1.185	0.170	0.129	-0.082	0.422	5.929	0.238
Career satisfaction	7	12	0.801	-0.222	0.080	-0.385	-0.060	4.944	0.040
Panel B: Teacher Qualifications									
Ability (test scores)	9	17	1.087	0.083	0.036	0.013	0.153	5.859	0.061
School selectivity	8	12	1.077	0.075	0.080	-0.081	0.231	5.733	0.386
Graduate (v. none)	24	38	0.987	-0.013	0.076	-0.145	0.119	15.789	0.866
Standard certification	21	26	0.583	-0.540	0.194	-0.876	-0.204	18.693	0.012
Specialty (STEM)	27	45	1.115	0.109	0.031	0.055	0.162	16.481	0.003
Specialty (Spec ed)	12	17	1.136	0.127	0.039	0.055	0.200	7.763	0.012
Experience (cont.)	13	21	1.003	0.003	0.019	-0.032	0.038	9.542	0.894
Experience (<3)	14	29	1.490	0.399	0.093	0.232	0.566	10.221	0.001
Panel C: School Organizational Characteristics									
School size	13	14	1.001	0.001	0.001	-0.001	0.002	2.773	0.457
Urban	13	14	1.048	0.047	0.075	-0.088	0.182	10.387	0.545
High school v. elem	7	9	1.122	0.115	0.085	-0.063	0.292	4.324	0.244
Secondary v. elem	14	20	1.138	0.129	0.070	0.001	0.257	9.532	0.099
Admin. support	13	19	0.806	-0.216	0.075	-0.354	-0.077	8.537	0.019
Induction/mentoring	11	26	0.753	-0.284	0.059	-0.399	-0.169	5.929	0.003
Panel D: School Resources									
Class size	8	9	1.006	0.006	0.005	-0.007	0.020	2.567	0.331
Panel E: Student Body Characteristics									

Student achievement	15	30	0.993	-0.007	0.005	-0.017	0.002	5.523	0.180
Percent Black	9	15	1.005	0.005	0.003	-0.003	0.013	1.973	0.195
Percent Hispanic	8	14	1.011	0.011	0.011	-0.024	0.047	1.784	0.430
Percent Minority	15	22	0.992	-0.008	0.039	-0.081	0.065	7.973	0.839
Percent FRPL	17	24	1.006	0.006	0.003	<.001	0.012	8.741	0.092
Panel F: Workforce									
Teacher effect. score	8	22	0.949	-0.052	0.040	-0.152	0.048	2.639	0.296
Merit pay (linear prob.)	10	14	.	-0.016	0.006	-0.028	-0.004	5.838	0.040
Salary	30	50	0.980	-0.020	0.004	-0.027	-0.013	11.215	<.001

Note. Assumed correlations between multiple, within-study outcomes is 0.5. Results are substantively similar for rho of 0.8.

Appendix Table 7

Determinants of teacher attrition and retention using “Leavers only” estimations (without leavers and switchers combined as one group) and includes hazard ratios

Factor	# of studies	# of ES	Main effect estimates					
			Odds ratio	Logged odds ratio	SE	Lower bound	Upper bound	p
Panel A: Teacher Characteristics								
Age (continuous)	12	12	0.979	-0.021	0.009	-0.039	-0.003	0.022
Age (greater than 28)	11	11	0.629	-0.464	0.123	-0.705	-0.222	<.001
Male	42	42	0.974	-0.026	0.041	-0.107	0.054	0.521
Minority (Black)	17	17	0.991	-0.009	0.187	-0.374	0.357	0.963
Minority (Hispanic)	13	13	0.562	-0.576	0.154	-0.877	-0.275	<.001
Minority (non-white)	11	11	0.852	-0.160	0.120	-0.396	0.076	0.183
Married	7	7	1.164	0.152	0.099	-0.042	0.346	0.125
Number of children	4	4	0.501	-0.692	0.165	-1.015	-0.369	<.001
Young child	3	3	0.551	-0.596	0.153	-0.896	-0.296	<.001
Career satisfaction	5	5	0.828	-0.189	0.071	-0.329	-0.050	0.008
Full time teaching	7	7	0.604	-0.504	0.132	-0.763	-0.245	<.001
Distance to school	2	2	0.987	-0.013	0.033	-0.078	0.052	0.704
Panel B: Teacher Qualifications								
Ability (test scores)	9	9	1.095	0.091	0.044	0.005	0.176	0.038
School selectivity	6	6	1.055	0.053	0.086	-0.116	0.222	0.537
Graduate (MA/PhD v none)	20	20	0.964	-0.037	0.076	-0.187	0.112	0.626
Graduate (MA/PhD v BA)	5	5	0.955	-0.046	0.166	-0.371	0.280	0.784
National Board	3	3	0.795	-0.230	0.464	-1.139	0.679	0.620
Teaching Fellow/TFA	3	3	1.096	0.091	0.542	-0.972	1.154	0.866
Highly qualified (NCLB)	1~	1	1.288	0.253	0.095	0.067	0.439	0.008
Internship	2	2	0.965	-0.036	0.015	-0.065	-0.007	0.014
Standard certification	17	17	0.511	-0.671	0.222	-1.107	-0.236	0.002
Specialty (STEM)	22	22	1.138	0.129	0.034	0.063	0.195	<.001
Specialty (Special ed)	9	9	1.098	0.093	0.039	0.017	0.170	0.017
Specialty (other)	5	5	1.240	0.215	0.031	0.155	0.276	<.001
Experience (cont.)	9	9	0.978	-0.022	0.015	-0.051	0.007	0.136
Experience (<3)	11	11	1.686	0.522	0.106	0.315	0.730	<.001

Panel G: Accountability

Assessment impact	4	4	0.981	-0.019	0.006	-0.031	-0.008	0.001
Teacher effectiveness score	6	6	0.876	-0.133	0.070	-0.270	0.005	0.058
Principal effectiveness score	1~	1	0.700	-0.357	0.108	-0.569	-0.144	0.001
Merit pay	2	2	0.739	-0.302	0.197	-0.689	0.084	0.126
Merit pay (LPM)	10	14	.	-0.015	0.005	-0.026	-0.005	0.005
Panel H: Workforce								
Employment rate	2	2	0.995	-0.005	0.025	-0.055	0.045	0.842
Retention bonus	2	2	0.940	-0.062	0.030	-0.122	-0.003	0.040
Non-teacher salary	4	4	0.735	-0.308	0.196	-0.693	0.076	0.116
Salary	25	25	0.982	-0.018	0.004	-0.025	-0.010	<.001
Union	1~	1	0.568	-0.566	0.144	-0.848	-0.283	<.001

Note. Estimates assume dependent effect sizes with within study correlation of 0.5. . ~Single study estimate, not meta-analytic results.

Appendix Table 8

Determinants of teacher attrition and retention using “Switchers only” estimations and include hazard ratios

Factor	# of studies	# of ES	Main effect estimates					
			Odds ratio	Logged odds ratio	SE	Lower bound	Upper bound	p
Panel A: Teacher Characteristics								
Age (continuous)	7	7	0.979	-0.021	0.012	-0.045	0.003	0.089
Age (greater than 28)	4	4	0.179	-1.721	1.627	-4.911	1.469	0.290
Male	19	19	1.071	0.069	0.028	0.015	0.123	0.012
Minority (Black)	12	12	1.053	0.052	0.324	-0.583	0.687	0.872
Minority (Hispanic)	9	9	0.709	-0.344	0.212	-0.759	0.072	0.105
Minority (non-white)	4	4	1.278	0.245	0.112	0.026	0.464	0.028
Married	2	2	0.715	-0.335	0.087	-0.506	-0.164	0.000
Young child	1~	1	0.740	-0.301	0.091	-0.480	-0.122	0.001
Career satisfaction	3	3	0.811	-0.210	0.107	-0.420	0.001	0.051
Full time teaching	3	3	0.686	-0.377	0.245	-0.858	0.104	0.125
Distance to school	3	3	1.035	0.035	0.043	-0.049	0.118	0.417
Panel B: Teacher Qualifications								
Ability (test scores)	5	5	0.992	-0.008	0.008	-0.023	0.008	0.342
School selectivity	2	2	1.049	0.048	0.125	-0.197	0.293	0.701
Graduate (MA/PhD v none)	11	11	1.200	0.182	0.080	0.026	0.338	0.022
Graduate (MA/PhD v BA)	1~	1	1.292	0.256	0.181	-0.099	0.611	0.157
National Board	2	2	1.552	0.439	0.209	0.030	0.849	0.035
Teaching Fellow/TFA	1~	1	0.940	-0.062	0.272	-0.595	0.471	0.820
Standard certification	8	8	0.794	-0.231	0.135	-0.496	0.034	0.088
Specialty (STEM)	9	9	1.188	0.172	0.037	0.099	0.246	0.000
Specialty (Special ed)	3	3	1.244	0.218	0.150	-0.075	0.512	0.144
Specialty (other)	1	1	1.009	0.009	0.105	-0.197	0.215	0.932
Experience (cont.)	5	5	0.948	-0.054	0.030	-0.112	0.005	0.071
Experience (<3)	6	6	0.822	-0.196	0.198	-0.583	0.192	0.323
Panel C: School Organizational Characteristics								
School size	8	8	1.001	0.001	0.003	-0.005	0.007	0.796
Urban v. rural	7	7	0.894	-0.112	0.027	-0.164	-0.060	0.000
High school v. elem	6	6	0.932	-0.071	0.167	-0.397	0.256	0.672

Middle school v. elem	5	5	1.092	0.088	0.082	-0.073	0.249	0.284
Secondary v. elem	6	6	1.029	0.029	0.089	-0.146	0.204	0.744
Private v. trad public	1~	1	0.677	-0.390	0.486	-1.343	0.563	0.422
Student disciplinary problem	3	3	1.349	0.299	0.217	-0.127	0.725	0.169
Better work environment	3	3	0.861	-0.149	0.122	-0.388	0.089	0.220
Administrative support	6	6	0.809	-0.212	0.075	-0.360	-0.064	0.005
Teacher collaborations	2	2	1.061	0.059	0.177	-0.287	0.405	0.738
Teacher leadership	3	3	0.968	-0.033	0.072	-0.174	0.109	0.651
Professional development	1~	1	0.974	-0.027	0.007	-0.040	-0.013	0.000
Induction/mentoring	2	2	1.131	0.123	0.181	-0.232	0.479	0.497
Classroom autonomy	4	4	0.899	-0.107	0.023	-0.152	-0.061	0.000
Panel D: School Resources								
Expend. support per teacher	1~	1	0.952	-0.049	0.018	-0.085	-0.013	0.008
Class size	5	5	0.980	-0.020	0.011	-0.042	0.002	0.079
Teaching materials	1~	1	1.090	0.086	0.063	-0.037	0.209	0.172
Panel E: Student Body Characteristics								
Student achievement	8	8	0.968	-0.032	0.018	-0.066	0.002	0.066
Percent Black	7	7	1.018	0.018	0.012	-0.005	0.041	0.125
Percent Hispanic	5	5	1.011	0.011	0.049	-0.085	0.106	0.828
Percent Minority	12	12	0.998	-0.002	0.005	-0.013	0.008	0.671
Percent FRPL	13	13	1.001	0.001	0.003	-0.005	0.008	0.710
Poverty	2	2	2.368	0.862	0.414	0.051	1.673	0.037
Percent IEP/LEP	5	5	0.979	-0.021	0.096	-0.209	0.166	0.823
Panel F: Relational Demography								
Race/gender congruence	2	2	0.815	-0.205	0.217	-0.630	0.220	0.344
Panel G: Accountability								
Teacher evaluation	4	4	0.951	-0.050	0.038	-0.125	0.025	0.192
Teacher effectiveness score	7	7	0.846	-0.168	0.072	-0.309	-0.026	0.020
Principal effectiveness score	1~	1	2.054	0.720	0.219	0.291	1.149	0.001
Merit pay	2	2	1.540	0.432	0.342	-0.238	1.101	0.206
Panel H: Workforce								
Employment rate	3	3	0.994	-0.006	0.012	-0.029	0.017	0.603
Late hiring	1~	1	1.490	0.399	0.100	0.203	0.595	0.000

Retention bonus	1~	1	0.942	-0.060	0.040	-0.138	0.018	0.134
Non-teacher salary	2	2	1.299	0.262	0.113	0.040	0.483	0.021
Salary	11	11	0.991	-0.010	0.005	-0.019	-0.000	0.045
Union	2	2	0.506	-0.682	0.096	-0.870	-0.493	0.000

Note. Estimates assume dependent effect sizes with within study correlation of 0.5. . ~Single study estimate, not meta-analytic results.

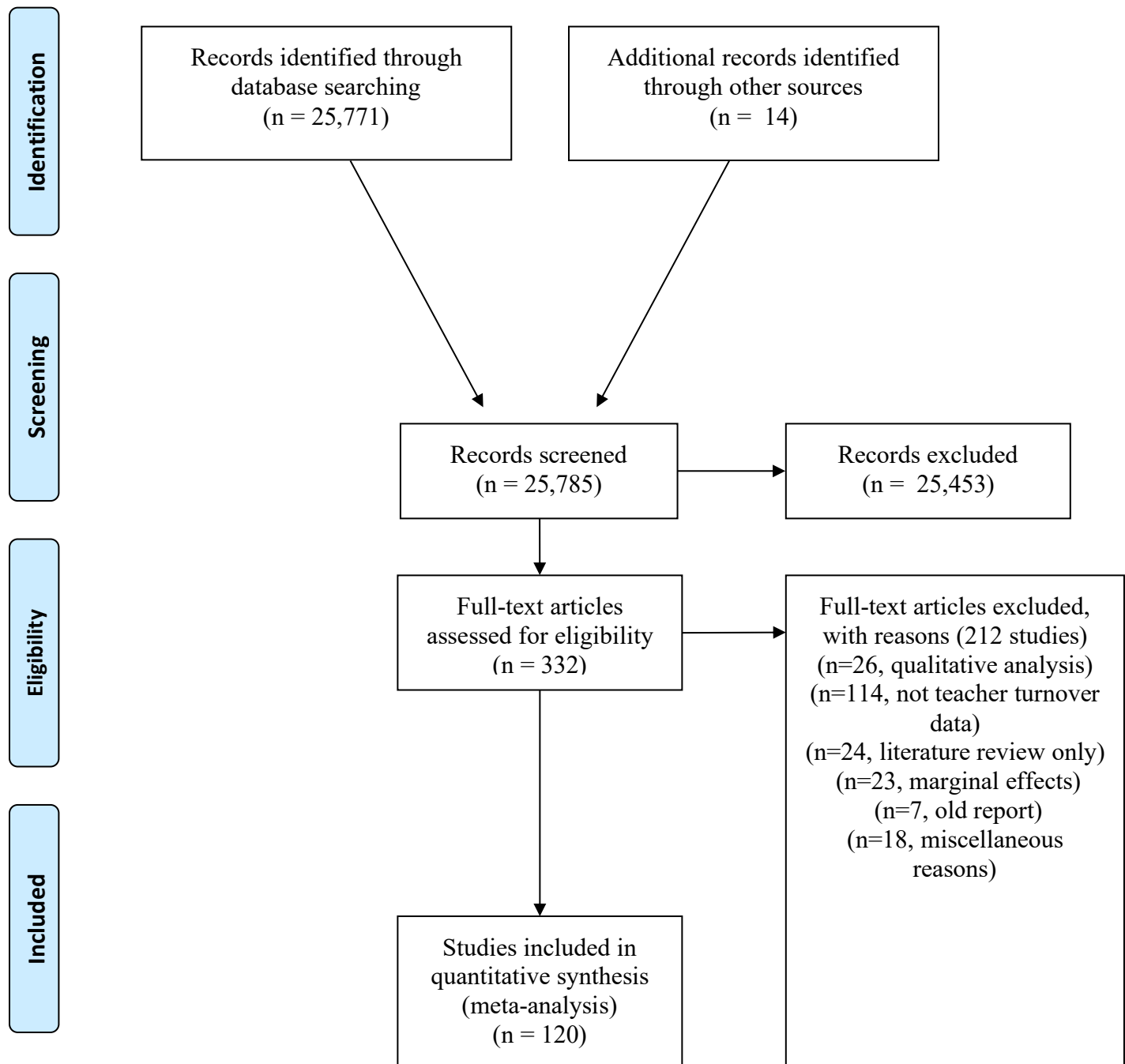
Appendix Table 9

Bivariate meta-regression results

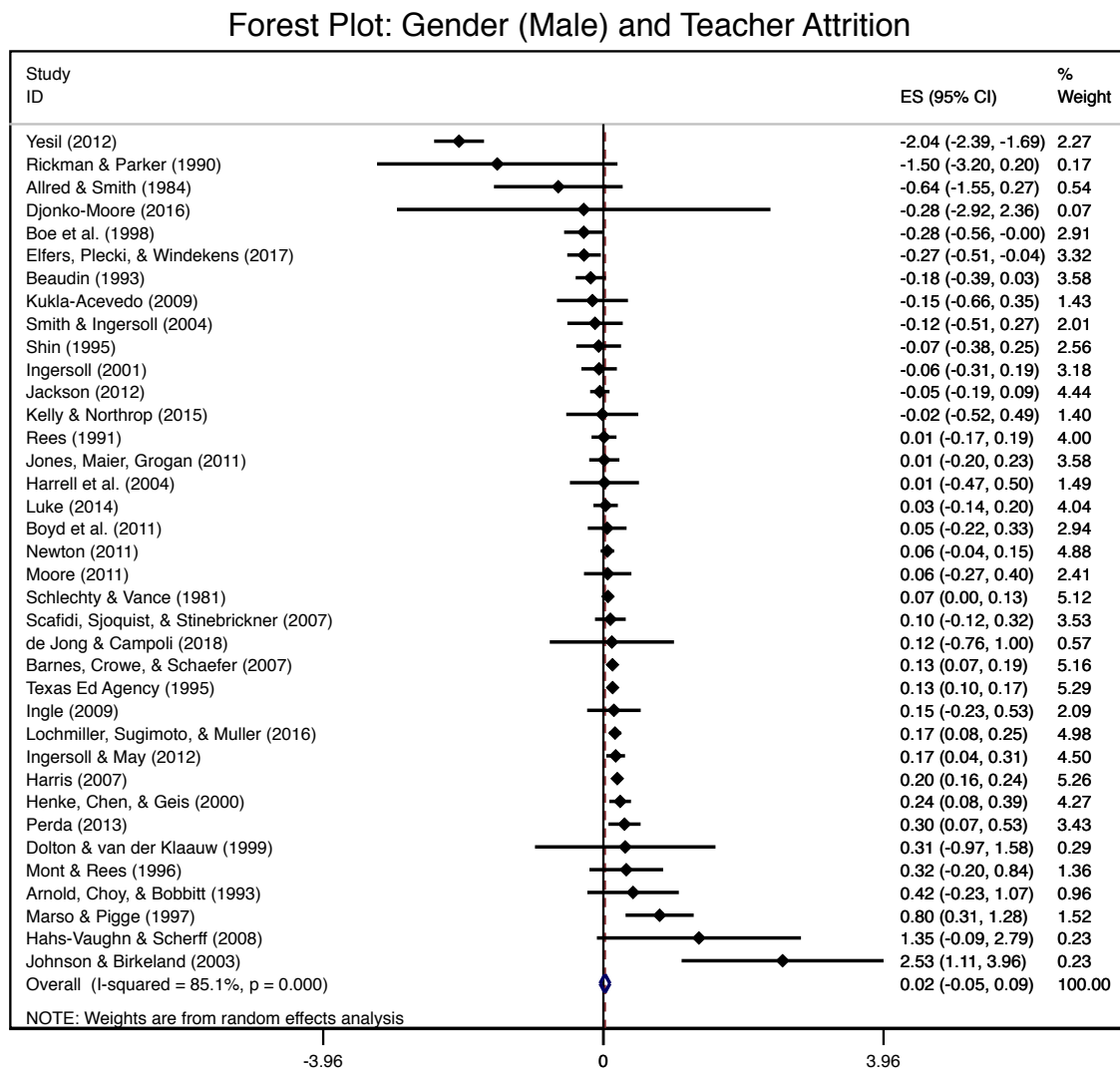
Factor	Longitudinal indicator	Big data indicator	Peer review indicator	Study quality indicator	After 2005	N
Age (cont.)	-0.033	-0.123	-0.034	0.069	0.066	14
Age (greater than 28)	0.252	0.2	0.148	0.174	-0.036	14
Male	0.096	0.031	-0.06	0.045	0.043	51
Minority (Black)	-0.467	-0.053	0.217	-0.158	0.488	23
Minority (Hispanic)	0.746	0.57	-0.08	0.481*	-0.354	19
Minority (non-white)	0.301	0.115	0.48	0.155	-0.108	13
Ability (test scores)	0.116 ⁺	0.071	-0.255*	0.014	0.091	9
School selectivity	0.014	0.009	-0.23	0.149	0.247 ⁺	8
Graduate (v. none)	-0.16	-0.036	0.025	-0.092	-0.146	24
Standard certification	-0.17	0.395	-0.357	0.298*	-0.016	21
Specialty (STEM)	-0.04	-0.053	-0.104	-0.057 ⁺	-0.084	27
Specialty (Spec ed)	-0.062	-0.017	0.142*	0.071	-0.097	12
Experience (cont.)	-0.017	0.012	-0.006	0.004	-0.04	13
Experience (<3)	-0.091	-0.091	0.101	-0.127*	-0.304	14
Urban	0.171	0.297*	0.102	0.025	0.127	13
Secondary v. elem	-0.304 ⁺	-0.203	0.007	-0.133**	-0.336*	14
Admin. support	0.034	-0.003	0.011	<.001	0.051	13
Induction/mentoring	0.298**	-0.056	-0.014	<.001	-0.101	11
Class size	-0.073 ⁺	-0.025	-0.054	-0.022	0.042	8
Student achievement	-0.101	-0.101	0.145	-0.182	0.156	14
Percent Black	-0.007	-0.007	-0.441	<.001	-0.22	9
Percent Minority	0.206	0.077	0.191	0.231	-0.305	15
Percent FRPL	<.001	0.004	-0.011	-0.004	0.008	17
Salary	-0.01	0.003	0.036	0.001	-0.007	30

Note. ⁺ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

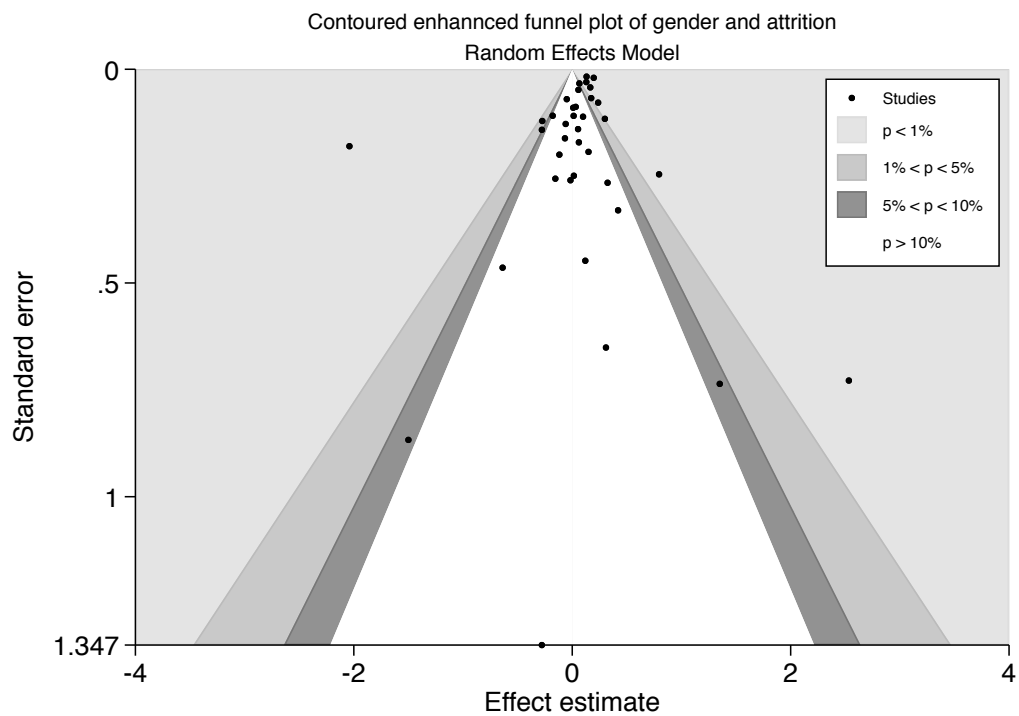
Appendix Figures

**Appendix Figure 1. Flow diagram**

This diagram depicts the literature screening process resulting in the final sample of primary studies included in the quantitative analysis. Adapted from Moher et al. (2009).



Appendix Figure 2. Forest plot for effect estimates of gender (male) on teacher attrition from primary studies.



Appendix Figure 3. Contoured enhanced funnel plot of gender (male) and attrition