EXAMINATION OF THE NU DATA KNOWLEDGE SCALE

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Jonathon Sikorski

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Jonathon Sikorski, Ph.D.

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Advisor: Beth Doll

There is a pervasive need for school systems to empirically and reliably assess the data literacy and data use skills of their educators (Ingram et al., 2004). With the federal government holding states and school districts accountable for student achievement and the increased emphasis of high stakes testing in schools, it is also critical to be able to precisely and accurately assess the skill and knowledge level of educators by measuring their overall data literacy. Disentangling these skills and abilities is a difficult task and, to date, no empirical measure of data literacy has been established. A strong measure of data literacy would have an empirical evidence base, have items that are reliable and internally consistent, and be recognized by experts in the scientific community as being empirically valid and conceptually sound.

The focus of this dissertation is the development of the NU Data Knowledge Scale: A measure of teachers' data use skills and knowledge. The psychometric properties of the NU Data Knowledge Scale were thoroughly examined in this dissertation. First, the test items were based off the databasics, and were independently categorized by subject matter experts. The measure was revised based off of the recommendation of the subject matter experts. The survey was sent to 215 rural Nebraskan teachers along with a demographics section and "Comfort with Data Use" questionnaire. The psychometric properties of the measure were discussed that related the internal consistency, item-total correlations, item difficulty, and item discrimination. The

dimensionality of the scale was explored using weighted least means squares analysis and the factor solution was determined by computing a parallel analysis. Fourteen predictors of teacher data literacy were then analyzed through an all possible regression procedure and the top model was chosen based off the Mallow's Cp and adjusted R^2.

Overall, the NU Data Knowledge Scale was found to be a single factor measure of data literacy. The predictors included in this model, though significant, did not provide practical significance in predicting scores on the measure. The limitations of the study, direction for future search, and implications for future practice are discussed.

TABLE OF CONTENTS

Tables

Figures

Appendix

CHAPTER ONE: IMPORTANCE

The demands on educators to look beyond student tests scores have never been higher. Educators today must be able to screen, give benchmark assessments, analyze graphs, and integrate data from multiple sources to describe the ability level of students (Jacobs, Gregory, Hoppey, & Yendol-Hoppey, 2009). Educational reform stemming from the No Child Left Behind Act (NCLB; 2001) has pushed educators away from using subjective measures of student progress (i.e., observations, gut feelings, and opinions) towards more rigorous, empirical approaches (Dunn, Airola, Lo, & Garrison, 2013; Stockard, 2013). NCLB legislation mandates students achieve specific benchmarks on high stakes assessments which increases pressure on schools to use student data well (Thorndike & Thorndike-Christ, 2010; Wayman, Spikes, & Volonnino, 2013). As a result, school districts seek out teacher development programs and assessment practices that require teachers to examine, gather, and interpret student data effectively (Mandinach & Gummer, 2013b; Qin & D'Ignazio, 2010). Indeed, educators who are adequately trained in effective data use strategies are better able to make educational decisions for students that are empirically based (Wayman et al., 2013).

In educational settings, data literacy research has become a focal point for discussion as school systems attempt to become more data driven and evidence based (Duncan, 2009). High stakes testing has put pressure on educators to meet performance-based standards at the district, state, and federal level (Mertler & Campbell, 2005). Unfortunately, data use strategies and skills have not translated into educator training and preparation programs (Dunn et al., 2013). Consequently, school districts have been

responsible for training a majority of their teaching staff in the latest evidence-based approaches (Wayman et al., 2013).

Data is an umbrella term used to describe a variety of information gathering tools. In school settings, student data is multifaceted and can include: archival student data such as student records, Individualized Education Program (IEP) goals, and standardized test scores; permanent products such as classroom assignments or projects; observational data such as student behavior; and cognitive ability scores from test scores, intelligence tests, and standardized assessments (Choppin, 2002). Teachers who are well versed in collecting and organizing student data from multiple sources are better able to differentiate instruction to meet the needs of their students and schools (Means, Chen, DeBarger, & Padilla, 2011). One promising teacher training program that taught teachers how to use multiple sources of data to strengthen student success was the NU Data Intervention (Doll et al., 2010).

The NU Data Intervention

The NU Data Intervention is a professional development program with the purpose of strengthening teachers' use of student data (Doll, Horn, & Shope, 2010; Sikorski, Doll, Thomas, Franta, & Kenney, 2013). The NU Data intervention is salient to data literacy research as it provides teachers opportunities to implement the six DataBasics through developmental instruction via weekly check-ins, site visits, and three seminars (Doll, Franta, Thomas, Chapla, & Sikorski, 2014; Sikorski, Franta, & Doll, 2014). This blended approach helped the researchers overcome the distance barriers of consulting with rural schools. As a result, teachers were able to develop data literacy and matriculate into local data experts in their schools (Doll et al., 2010). This reduced the

need for teachers to rely on external expert consultants and strengthened schools' resilience.

Results of the Doll et al. (2010) study showed promise that teachers' data use knowledge, skills, and beliefs improved during participation in the NU Data intervention. In particular, a measure of teachers' data literacy assessed their knowledge of the six Databasics: (1) knowledge of diverse data collection protocols; (2) selecting protocols best suited to answer teachers' questions; (3) collating and graphing data; (4) discerning trends and differences in data; (5) using data in team problem-solving; and (6) selecting evidence-based interventions. Teachers' knowledge of the six DataBasics increased after NU Data training, as did their ratings of the acceptability and likely impact of data-informed instructional modifications. Higher scores for teachers' data use during the project predicted greater student progress towards teacher selected goals. Moreover, pre-, during, and post-examples of teachers' data use showed that their fidelity to standards for high quality data was stronger after completing the NU Data intervention, and these gains were maintained one year after the NU Data Intervention ended (Sikorski et al., 2013). Teachers who participated in the intervention reported having more confidence in their data use skills. Some teachers went on to become data ambassadors in their schools by hosting teacher development programs to teach their staff about the databasics and NU Data intervention.

Purpose of this study

The purpose of this study is to examine the psychometric properties of the NU Data Knowledge Scale, the measure that was developed to assess knowledge outcomes of the NU Data intervention. This dissertation has the following research goals:

1. To assess the overall internal consistency of teachers' scores on the NU Data Knowledge Scale instrument.
2. To assess the capacity of items to discriminate teachers' knowledge of the Databasics; and
3. To describe the descriptive and demographic statistics of the instrument with the sample of teachers.

CHAPTER TWO: LITERATURE REVIEW

The purpose of this study is to examine the psychometric properties of the NU Data Knowledge Scale as a measure of the data literacy of teachers. The previous chapter provided a brief overview of factors in the national educational climate that have increased efforts to measure teachers' data literacy. This chapter will review research related to data literacy, teachers' basic understanding of data, and teachers' data knowledge of the databasics. Additionally, this chapter will describe the databasics that underline the NU Data intervention, the development of the NU Data Knowledge Scale, and components of strong measures.

Data Literacy

The United States Department of Education has invested over 700 million dollars into teacher development programs to increase teachers' knowledge of and familiarity with accessing and interpreting student data at the student, classroom, school, and national level (Lai & Hsiao, 2014). Despite this funding, 72 percent of school districts cited deficiencies in teacher knowledge and skills in data use as barriers to using data effectively in schools (U.S. Department of Education, 2008). As a result, the U.S. Department of Education reinforced the No Child Left Behind Act of 2001's mandate that required teachers to demonstrate deeper understanding of basic assessments and statistical concepts, and fluency in reading and understanding a variety of data representations (i.e., tables, charts, dashboards, database interfaces, and graphing programs; Bakx, Baartman, & van Schilt-Mol, 2014; Means, Chen, DeBarger, & Padilla, 2011; U.S. Department of Education, 2008). Teachers who are fluent in reading, collating, and interpreting student data are better able to apply interventions in response

to the data which can result in better outcomes for students (Christoforidou, Kyriakides, Antoniou, & Creemers, 2014).

Defining Data Literacy. To meet the growing demands of national educational policy, districts sought opportunities to increase the assessment literacy, data-based decision making skills, and teacher knowledge of and familiarity with multiple data use strategies. The term data literacy has been defined many different ways in research, and has often been used as a synonym for assessment literacy, data-based problem solving, data use skills, and formative and summative assessments (Mandinach & Gummer, 2012; Mandinach & Gummer, 2013a; Mandinach, Honey, & Light, 2006; Means et al., 2011; Penuel, Roschelle, & Shechtman, 2007; Stephens et al., 1995; Stiggins, 1995). It has become increasingly important to differentiate data literacy from other forms of data use and teacher knowledge (Mandinach & Gummer, 2013a).

The most widely-quoted definition of data literacy is the ability to understand and use data effectively to inform decisions (Mandinach & Gummer, 2013a). Although concise, this definition does not adequately capture the complexity of data literacy, and has added to the confusion over how data literacy differs from other aspects of data use.

Data literacy is often conflated with assessment literacy in schools because schools heavily emphasize interpreting high-stake assessments (Mandinach, 2012; Mertler & Campbell, 2003, 2005). Assessment literacy examines teachers' abilities to (a) administer and score standardized tests; (b) recognize how their own biases affect interpretation; and (c) use data to guide instructional practices and make educational decisions for students (Jacobs et al., 2009; Mertler & Campbell, 2005). These abilities are also components of data literacy. However, assessment literacy refers to choosing,

selecting, and interpreting large data sets from summative assessments, whereas data literacy incorporates the synthesis multiple measures (i.e., formative assessments, classroom assignments, test scores, etc.) to ecologically examine students' abilities and behaviors (Christoforidou et al., 2014; Quilter & Gallini, 2000).

A key differentiation between data literacy and assessment literacy is data literacy's focus on a wide range of student data like formative assessments (Mandinach & Gummer, 2012), student perceptions (Love, 2011; Vahey, Rafanan, Patton, Swan, van't Hooft, et al., 2012), motivation (Qin & D'Ignazio, 2010; Schield, 2004), and the process of behavior (Mandinach & Gummer, 2013a). The U.S. Department of Education gathered 24 educational experts to define and identify the critical components of data literacy. During this meeting, 76 percent of experts believed that there was overlap between assessment and data literacy; they argued that the major difference from assessment literacy was data literacy's breadth and complexity in application across fields (Mandinach & Gummer, 2012).

Data literacy is also often confused with data-based decision making. Like data literacy, data-based decision making emerged out of federal policy changes and legislation that encouraged teachers and researchers to examine how data impacts educational decisions for students (Dunn, Airola, Lo, & Garrison, 2013). Federal legislation emphasized incorporating comprehensive student data into assessments instead of relying on only standardized assessments (Dunn et al., 2013; Newton, Algozzine, Algozzine, Horner, & Todd, 2011; Roehrig, Duggar, Moats, Glover, & Mincey, 2008). As a result, schools needed to broaden their assessment practices to include aspects of behavior and motivation (Duncan, 2009). The No Child Left Behind

Act also mandated that schools show that students make Adequate Yearly Progress (AYP) on high stakes assessments this mandate further pushed schools to provide teachers trainings and instruction in data use (Wayman et al., 2013).

To meet the new federal criteria for AYP and proficiency standards, districts • incorporated data-based decision making practices into their classrooms. According to the National Association of School Psychologists (NASP) best practices in data-based decision making practices require teachers to (Dunn et al., 2013; Ysseldyke et al., 2009): (1) conduct comprehensive evaluations of students that incorporate observations, interviews, and standardized assessments; (2) implement curriculum-based assessments, measurements, and evaluations to monitor student progress; (3) employ ecological assessments to measure the impact of the school environment on learning; and (4) differentiate instruction to meet the specific educational needs of students.

These four components are critical to understanding both data-based decision making and data literacy. Like data-based decision making, data literacy requires using a variety of data sources to make educational decisions for students (Jacobs, Gregory, Hoppey, & Yendol-Hoppey, 2009). Moreover, one aspect of data literacy is engaging in independent and collaborative team problem solving that translates student data into actionable practices (Mandinach & Gummer, 2013a). An important difference between data literacy and data-based problem solving is that data literacy focuses more broadly on basic teacher knowledge of data collection practices and skills; whereas data-based problem solving focuses more on the iterative process of data collection and hypothesis testing (Huguet, Marsh, & Farrell, 2014; Wayman & Jimerson, 2014). In this regard, data

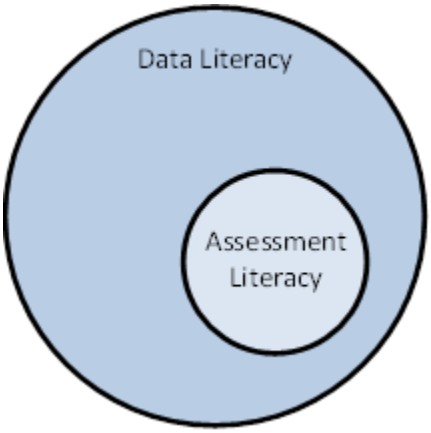
literacy looks beyond how teachers use student data and focuses on how teachers use student data well (Jimerson, 2014).

Data literacy is consistent with the Response to Interventions (RtI) framework for using student data to identify students for special educational services (Fuchs & Fuchs, 2006). The goal of RtI is to describe students' eligibility for special education by using curriculum based measures to monitor their progress in the classroom while implementing responsive classroom instruction that is sensitive to specific student needs (Ingram, Louis, & Schroeder, 2004). Likewise, data literate teachers are empowered to use student data in their classrooms to drive instruction, and to change educational practices to improve the educational outcomes of all students (Stephens et al., 1995). Indeed, RtI reflects many positive qualities of data literacy (i.e., actionable practices, progress monitoring, and changing educational practices in response to student data), and is an integral component of the data literacy framework.

In essence, data literacy may be thought of as the next iteration of assessment literacy, data-based decision making and RtI. Multiple illustrations have been attempted to distinguish data literacy from other forms of data use. One illustration that emerged from the U.S. Department of Education (2011) summit on data literacy was a Venn diagram (see Figure 1:1) in which assessment literacy is shown as housed within data literacy.

Figure 1:1

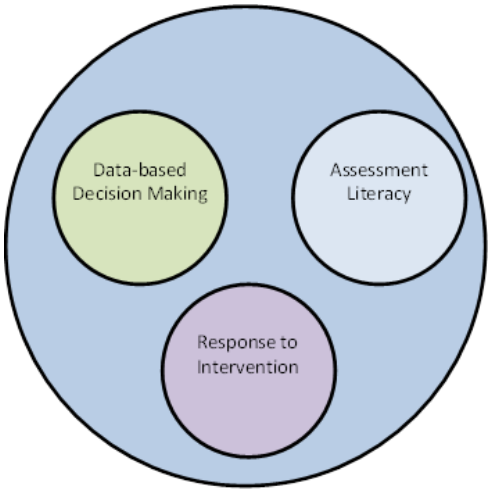
Venn diagram from (Mandinach & Gummer, 2013)



A majority of data use experts at the summit postulated that data literacy possessed all of the aspects of assessment literacy, and also had its own characteristics. Alternatively, data literacy can be described in a Venn diagram as comprising assessment literacy, data-based decision making, and actionable data use practices (see Figure 1:2). However, these diagrams do not go far enough in identifying the critical components of data literacy.

Figure 1:2

Revised Venn Diagram of Data Literacy



Components of Data Literacy. In order to be data literate, teachers need to have basic knowledge of data (Vahey, Rafanan, Patton, Swan, van't Hooft, et al., 2012), to apply and interpret sound data use techniques and information (Newton et al., 2011), and use the data they collect to guide future educational decisions. This review will describe three distinctive frameworks describing data literacy: The Mandinach and Gummer (2012) framework, the Means et al. (2011) framework, and the NU Data (Doll, 2010) framework.

There is growing consensus about which critical components of data literacy are most salient (Dunn et al., 2013). Mandinach and Gummer's (2012) framework postulated five critical components of data literacy: data location, data interpretation, data comprehension, question posing, and data use. These components were derived from conducting an extensive literature review of data literacy, data-based decision making, and teacher data use. In total, 41 books and 6 articles were reviewed and independently coded by Mandinach and colleagues (2012) until they arrived at the five outlined components. They defined data location as the ability to find the right kinds of data to answer specific questions. Data interpretation was defined as the ability to derive meaning from the data, and data comprehension was defined as knowing what the data say. Question posing was defined as the ability to use data to answer future questions, and data use was the ability to base future instruction, interventions, and planning based on student data. These components supported national efforts to support effective teacher data use in schools (Mandinach & Gummer, 2012).

Similarly, the Means et al. (2011) framework identified four content domains comprising data literacy. These included: Data Knowledge, content knowledge and

teacher; Data Focus, ability to access a variety of data protocols and assessment techniques; Problem Focus, ability to identify problem and formulate hypotheses; and Process Focus, collaborative inquiry, knowing how to solve data use problems (Means et al., 2011). These components were developed through consensus building strategies with 76 experts. Means and colleagues (2011) developed these components to address the missing emphasis on teacher data skills and data informed decision making in previous data literacy research.

Both the Mandinach and Gummer (2012) and Means and colleagues (2011) frameworks align across four broad domains. These domains are: (1) teachers need to have basic knowledge and skills in data use, (2) teachers need to be able to interpret the data they collect, (3) data needs to be used in classroom settings, (4) teachers need to be able to engage in data based problem solving.

Teachers need to have basic knowledge and skills in data use. The first broad component of data literacy describes foundational skills for teachers use and manipulation of basic forms of data (Means et al., 2011). Teachers need to be able to differentiate between measures of central tendency (i.e., mean, median, and mode) and understand how they are used (Dunn et al., 2013; Ingram, Louis, & Schroeder, 2004). They need to understand and be able to interpret graphs and other basic forms of student data. In educational settings, teachers must be able to understand, create, and manipulate data in graphs in order to understand student performance on progress monitoring curriculum-based measure and standardized assessments (Jacobs et al., 2009; Mandinach & Gummer, 2012; McCutchen et al., 2002).

This component represents the foundational knowledge of data use that teachers demonstrate throughout their careers. It is their familiarity with interpreting student grades, creating rubrics for assignments, and collecting behavioral and academic intervention data on students (Roehrig et al., 2008). This foundational knowledge is predicated on teachers' pre-service trainings and experiences in the classroom. Preliminary results from the NU Data intervention showed that teachers had some basic knowledge in data use, such as: knowing how to collect data on student behavior, academic progress, and efficacy; and teachers had a basic, but insufficient, knowledge of the databasics and data use strategies (Sikorski et al., 2013). Basic teacher knowledge in data use is essential for teachers to be able to use data effectively to increase the educational outcomes for students.

Teachers need to be able to interpret data they collect. The second domain of data literacy, data interpretation is defined as the teacher's ability to derive meaning from student data, protocols, and measures (Mandinach, 2012; Mandinach & Gummer, 2013a). Data interpretation skills are important for teachers to be able to draw qualitative and quantitative inferences from student data such as classroom observations, descriptions of student behavior, and hypothesis testing. Teachers who can interpret results from a variety of assessments, behavioral, academic, and formative measures are highly skilled (Means et al., 2011).

Preliminary results from the NU Data Intervention study (Doll et al., 2014) showed that teachers were missing critical skills in organizing and interpreting the data they collected on students prior to completing the NU Data intervention. After the

intervention, teachers were more skilled in assessing student data, but lacked the skill and knowledge to be able to apply interventions in response to student data.

Data needs to be applied in classroom settings. The third domain of data literacy is data application. Data application describes how well teachers apply data use skills within classroom settings. This is evident by teachers turning data into actionable practices. An example of data application would be a teacher adjusting their curriculum in response to student scores on a benchmark assessment. Teachers who are able to apply data use skills within the classroom are better able to differentiate instruction in response to student data to meet specific student needs (McCutchen et al., 2002; Roehrig et al., 2008). Data application skills are integral to RtI in which teachers monitor, track, graph, and interpret formative assessments, benchmark scores, and curriculum-based measures. Additionally, data application incorporates components of assessment literacy because it includes teachers' abilities to incorporate summative assessment results into curriculum planning, teaching pedagogy, and instruction (Jacobs et al., 2009; Lukin, Bandalos, Eckhout, & Mickelson, 2004; Smith, 2013).

Teachers also need to able to gather and synthesize multiple forms of data when assessing student progress (Mandinach, 2012; Mandinach & Gummer, 2013b; Roehrig et al., 2008; Smith, 2013). This ensures that adjustments made to student curriculum are based on a comprehensive review of student data from multiple sources, rather than from a single measure. Comprehensive evaluations synthesize data collected from direct and indirect sources, including: student records, grades, behavioral observations, formative and summative assessments, curriculum-based measures, rating forms, interviews, and

high stakes testing (Mertler & Campbell, 2003; Smith, 2013; Stephens et al., 1995; Ysseldyke et al., 2009).

Teachers need to be able to engage in Data-based problem solving. The fourth and final component of data literacy is data-based problem solving. Data-wise teachers are able to formulate hypotheses based off student data, collect meaningful baseline data, and change instructional techniques to meet individual student needs (Boudett, City, & Murnane, 2005). In RtI, data literate teachers use data-based problem solving strategies to set goals, monitor progress, and evaluate student outcomes. Data-based problem solving strategies incorporate continuous assessment strategies and iterative problem-solving techniques to answer hypotheses about students. Teachers participating in data-based problem solving strategies often collaborate with other professionals to examine data and dialogue (Newton et al., 2011). Because data literate teachers are experts in the use of student data, they are able to describe data to parents and other teachers in an easily understood way (Doll et al., 2005).

The Mandinach and Gummer (2012) and Means et al. (2011) frameworks adequately identified most of the critical components of data literacy. However, these critical components are not exhaustive and do not address some of the barriers to measuring and identifying data literacy. Additionally, researchers do not agree which data components stand alone and which components are interrelated with each other (Mandinach & Gummer, 2013b). Consequently, there are some gaps in published descriptions of the critical components of data literacy.

The first critical component not identified by these two definitions is the impact and importance of teacher training and development programs. Indeed, teacher

experiences are critical to developing the data literacy and data-based decision making ability of teachers (Love, 2004, 2011). However, there are no current educational standards in pre-service teacher courses that target data use skills (Jimerson, 2014; Staman, Visscher, & Luyten, 2014). As a result, teachers' mastery of data literacy is inconsistent when teachers first enter the workforce (Mandinach & Gummer, 2013b). This inconsistency results in teachers having different needs in data use trainings throughout their careers. The Council for Accreditation of Education Preparation (CAEP; Council for the Accreditation of Educator Preparation, 2013) mandated that teachers be able to use valid assessments and provide a rationale for using them in the classroom. However, this does not require teachers be data literate; rather it mandated programs to teach teachers to be articulate about assessment.

School districts have spent millions of dollars on professional development courses in data literacy (Jimerson, 2014; Lai & Hsiao, 2014). Unfortunately, these trainings are quite variable: 90 percent of school districts' professional development programs are provided to only a fraction of the school staff (Mandinach & Gummer, 2013b). This reinforces differential exposure to and attitudes towards data use in schools, and detracts from a culture of broad and shared responsibility for data (Jimerson, 2014). When requirements of teacher training programs are not systematic, teachers will not use consistent language when discussing student data, will implement different classroom behavioral and academic interventions, and staff-wide buy-in of intervention techniques is difficult (Staman et al., 2014).

A second limitation of the components of data literacy identified by the Mandinach and Gummer (2012) framework and Means et al. (2011) framework, is that

neither framework emphasized the importance of fostering cultures of support for data use (Jacobs et al., 2009; Jimerson, 2014). Schools create systematic support for data literacy among their staff by providing staff-wide trainings in data use and support (Love, 2004, 2011; Mandinach & Gummer, 2013b). There is a growing need for teacher training and preparation programs that schools could use to increase data literacy knowledge and skills of their teachers**.** This would provide teachers with a shared reference point when discussing student data and engaging in team-based problem solving.

DataBasics

An alternative framework of data literacy has emerged out of teacher consultation research conducted by Doll and colleagues (2005). The databasics are early and very basic data skills that provide critical foundations for data literacy as described by Mandinach and Gummer (2012) and Means et al. (2011). The databasics were developed by Doll et al. (2005) through a mixed-method study examining barriers that teachers faced when trying to implement high quality data use procedures with fidelity. The study conducted quantitative analyses of teacher surveys and qualitative analyses of focus groups transcripts from 76 teachers in 13 schools.

Analyses identified six strategies and skills that teachers believed would increase their data-based decision making skills. Doll et al. (2010) referred to these skills as databasics: (1) knowledge of diverse data collection protocols; (2) selecting protocols best suited to answer teachers' questions; (3) collating and graphing data; (4) discerning trends and differences in data; (5) using data in team problem-solving; and (6) selecting evidence-based interventions. Though developed as part of consultation research, Table