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An Improved Methodology for Advancing Nursing Research

Factorial Surveys

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Clinical judgments and decisions are an integral component of nurse work and nurses are increasingly being challenged to account for their judgments and decisions. Nursing research is needed to help explain judgment and decision making in nursing, but most research in this area is almost exclusively characterized by descriptive studies. This article describes the use of the factorial survey method, which combines the explanatory power of a factorial experiment with the benefits of a sample survey. This hybrid technique is an excellent method for studying judgments and decisions across settings, roles, disciplines, and countries. This article outlines the steps of the method and demonstrates its applicability with an exemplar from a study across nurses from 3 countries. **Key words:** *decision making*, *factorial survey*, *judgment*, *methods*, *nurses*, *nursing*, *nutrition*

RESEARCH designs that can attribute causal explanation when studying nurses' judgments and decision making are critical. The increased emphasis on continuity of care, interdisciplinary research, and the impact of globalization of healthcare have increased the need for research comparisons across settings, practice roles, cultures, and countries. Yet, high costs, the nature of the research, time constraints, and ethical concerns have hampered the use of experimental designs in nursing research on judgments, decision making, and comparative studies.

Clinical judgments and decisions are an integral component of nurse work and as such impact on care recipients, care providers, and the larger lay and health communities. All nurses, across practices, settings, and countries, make numerous judgments and decisions daily. Yet, much work needs to be done to explore how nurses make judgments and decisions, to examine the contextual nature of those judgments and decisions, and to examine nurse consensus and variation in judgment and decision making. The profession, the public, and the policymakers are increasingly asking nurses "... to account for the decisions they make for, with, and on behalf of, their patients."[1(p4)]

The factorial survey, which combines the advantages of the experimental design with the advantages of survey research, can be used to answer research questions that are concerned with judgments, decision making, and/or concept definition. The study of nursing decisions that may be threatening to patient outcomes such as the use of restraints, a

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referral to protective services, or refusal to medicate or treat a patient are just a few examples of the types of decisions that can be studied. Judgments might include asking nurses to assess substantive problems like elder abuse, acute confusion, or malnourishment. Concept differentiation might be determining which of the 2 competing diagnoses is depicted: abuse versus self-neglect or delirium versus dementia.

The purpose of this article is to demonstrate how nurses can use the factorial survey method, an advanced method used widely in the social sciences, effectively and efficiently in empirical nursing research to examine judgments and decision making. An overview of the factorial study design is provided and then followed with a brief overview of judgement and decision-making research. Finally, the key components of the factorial survey technique are presented: (1) operationalizing variables and writing a rational vignette, (2) producing randomly generated vignettes, (3) selecting a sample size and sampling, and (4) analyzing data. To illustrate the versatility of the factorial survey design and its application to clinical judgments, we use as an exemplar a study of nurse decision making about nutrition and with subjects across 3 countries. Nurses and nursing students from the United States, Northern Ireland, and Scotland participated in the study, which examined the impact of 11 clinical and sociodemographic patient variables for their impact on nurses' decision making regarding risk, screening, and referral for malnutrition.

FACTORIAL SURVEY DESIGN

The factorial survey combines the benefits of a factorial experimental research design with the benefits of a sample survey. The strength of the factorial survey is that it is a hybrid technique. It combines the strength of random assignment inherent in the classical experimental design with the generalizability power of the sample survey because of random sampling.

The traditional factorial experiment typically employs a 2 × 2 or a 2 × 3 factorial research design. The factorial survey, on the other hand, typically employs 10 to 15 independent variables. Moreover, the simple vignette design using 2 independent variables in a 2 × 2 factorial research design defines 4 cells. The factorial survey will define thousands or millions of cells. In the cross-country study employed here for illustration, there are 11 independent variables in the 8 × 5 × 2 × 5 × 3 × 12 × 3 × 4 × 5 × 5 × 3 factorial research design.

This factorial design is defined by 12,960,000 cells. A unique vignette could be produced for each of these 12.9 million cells. This is where the power of random sampling comes into play. A sample of cells (say 520) is randomly selected from the population of more than 12 million possible cells in the design. Thus, we have 1 cell per 25,000 possible cells in the sampling design. Given that these cells were randomly selected, main effects for 11 independent variables on the dependent variable(s) can be reliably assessed and evaluated for statistical significance. Moreover, the effects of the 55 first-order interactions on the dependent variable(s) can also be reliably assessed and evaluated for statistical significance.

The probability base of random sampling and the law of large numbers imply that there will be sufficient cases to assess these effects. Consider the 8 × 5 subfactorial design in the above-described model of 11 variables. It has 40 cells (8 × 5 = 40). With an *N* of 520, there are an expected 13 observations per cell (40 × 13 = 520). In reality, the number of observations per cell will be 13 plus or minus a few. This "plus or minus" is sampling error. The proportion of observations in each category of each variable hovers near the expected proportion that would have occurred given the random sampling design of people in the population. The same principle applies to the factorial survey. The proportion of observations in each cell hovers near the expected proportion that would have occurred given the random sampling design of cells in the factorial survey universe.

The survey design evolves from the vignette, which is the basic element in the factorial survey technique. Like any survey, this method can be paper and pencil or electronic and thus self-administered or administered by a researcher via phone or face-to-face. A chief feature of survey research is the ability to use probability sampling. Traditional probability sampling selects a sample of respondents from a population of potential respondents. Probability sampling in the factorial survey selects a random sample of vignettes from a population of potential vignettes. Research using the factorial survey can also take advantage of traditional probability sampling to increase the generalizability of the results. The survey nature of the design allows for ease of administration across settings, practices, and professions, and even across countries as we demonstrate in this article.

The assets derived from the factorial design and the survey can simultaneously increase internal and external validity. The internal validity is increased because the values of the independent variables vary randomly across the spectrum and are not limited to the variance of these variables in any specific clinical population. In addition, the effects of demographic and social variables (eg, age, sex, race, socioeconomic status) that are so often alleged to influence such judgments and so rarely tested can be included as independent variables. Moreover, each vignette is unique and the set of vignettes to which any respondent answers is also unique. The external validity or generalizability is increased as the survey aspect of the design facilitates the sampling design.

The factorial survey was first developed by Rossi and Anderson[2] to examine social judgments and has primarily been used across the social sciences to investigate the social definitions of a wide variety of behaviors and decision making by a number of varying professionals and laypersons. The factorial survey has been used to examine a variety of problems, including child abuse,[3,4] sexual harassment,[5] and mental illness.[6] More recent work includes investigation of topics like self-neglect,[7,8] use of restraints on patients,[9,10] child abuse recognition by nurses,[11] and health professionals' beliefs about factors affecting health behaviors of clients.[12] Although the factorial survey has been widely used in social science, its use in nursing[13] and in other health professions[12] has been virtually nonexistent.

A search of major literature databases in the social and health sciences (*MEDLINE, CINAHL, Soc Sci, PsychINFO*) produced approximately 130 articles that feature factorial surveys. However, published nursing research reflects that the technique is not well known in nursing. Only 6 factorial survey articles appear in nursing journals and the method is not explained in major nursing research methods books, reflecting that many nurse researchers have had limited, if any, exposure to this experimental method.[14]

JUDGMENT AND DECISION-MAKING RESEARCH

The literature on judgment and decision making in nursing is characterized by a number of expressions used to explain the same phenomenon, such as clinical decision making,[15] clinical judgment,[16,17] clinical inference,[18] clinical reasoning,[19] and diagnostic reasoning.[20] In essence, what all of these types of studies are investigating are how nurses make judgments "the assessment of alternatives" and decisions "choosing between alternatives"[21] about patients under their care. The study of judgment and decision making has been the focus of attention for researchers for over half a century,[1] with a number of theories describing how decisions are made in practice (descriptive approaches), how they should be made (normative approaches), and how they may be improved and/or generated as a result (prescriptive approaches).

The research into judgment and decision making in nursing is almost exclusively characterized by descriptive studies that examine how nurses make judgments and decisions in practice. These studies have commonly used a mixture of observation of practice and interview to examine various characteristics of nurse decision making, such as expertise,[16,22–26] the role of heuristics and bias,[27,28] and task complexity.[29,30] Some of the studies use vignettes as the basis for data collection, examining how nurses may make judgments and decisions in practice.[23,31,32] All of these studies have provided valuable evidence regarding the nature of nursing expertise[22] and influences on decision making practice.[27,33] However, because they are descriptive studies, they are characterized by small, unrepresentative samples, and are unable to identify systematic differences in the way nurses use information to make judgments and decisions, or variability in decision making. Other studies have used surveys to explore nurse decision making.[34,35] However, these surveys rely on self-report of "general" strategies that nurses say they use in decision-making situations, without any reference to possible behavior or patient context. As it is commonly recognized that individuals' insight into their decision-making ability is often limited, the results of this type of study are also problematic, as they cannot provide an insight into actual nurse behavior.

Designs that use the factorial survey approach can help address the criticisms of existing research into judgment and decision making in nursing. By using vignettes to mimic patient scenarios, researchers have a tool that can mirror the "real life" experiences of those knowledgeable in their fields while maintaining a valid research design. The systematic nature of the design of the factorial survey allows for the representative sampling of a population, the examination of information cues used by nurses in detail, and the identification of similarities and differences in approaches to judgment and decision making.

VARIABLES AND WRITING A RATIONAL VIGNETTE

The factorial survey uses a vignette that is created from the independent variables chosen for the study. This approach facilitates examination of wide categories of contextual information about a problem/case or patient. The factorial survey method was developed to examine the effects of numerous interdependent pieces of data that are often seen in the real world, but are often multicollinear. The power of the factorial survey design lies in the ability to examine normative beliefs of a group about a concept, judgment, or a decision, but unlike the real world, the independent variables are virtually uncorrelated in the factorial survey. Thus, crucial to the method is writing a vignette that tells a logical story and that includes all the variables that are to be tested. Thus, identification of the independent variables and their levels is a basic step in developing the vignette and its framework.

Independent variables

The uniqueness of each vignette lies in how the story is made to vary by the levels of the independent variables. Each vignette can be simple or complex, depending on the number and types of independent variables chosen. The main character (eg, patient/client if looking at nurse decision making about patients) can be made to vary by diagnosis, affect, gender, etc. The number of independent variables can easily be as high as 10 to 15, and 2 to 3 dependent variables have been used by researchers. The independent variables that operationalize the vignette are drawn from research and the literature. (See Table 1 for example of dietary, anthropometric, biochemical, clinical, and sociodemographic independent variables used in exemplar.)

Once the independent variables are selected, the levels of the variables must be determined. Age, for example, is a common patient characteristic that nurses are often interested in. The levels for age would be set based on the ages one is interested in studying. In the cross-country study on nutrition, the levels of age we used were 25, 35, 45, 55, 65, 75, 85, and 95. Nominal variables such as gender can also be used. An interesting level that can also be introduced is the null category. The null category can provide some useful information in a factorial survey. For example, gender is a commonly used variable across many studies, and the

Table 1. Dietary, anthropometric, biochemical, clinical, and sociodemographic independent variables

Independent variables	Levels	Values of independent variables	Rationale for inclusion
Age, y	8	25, 35, 45, 55, 65, 75, 85, 95	Effect of age on nutritional status[36,37]
Marital status	5	Single, married, widowed, separated, divorced	Social factor in nutrition[38]
Gender	2	Male, female	Social factor in nutrition[38]
Diagnosis	5	Congestive heart failure, chronic obstructive pulmonary disease, inflammatory bowel disease, type 2 diabetes mellitus, chronic renal failure	Nutrition related[37,39]
Assessment phase	3	An initial nursing assessment of the patient, a review of the patient's progress, a final nursing assessment before the patient is discharged	New variable entered because of emphasis on discharge planning[37]
Height and weight	12	Three weights for each of 4 heights (expressed in pounds and inches for vignettes used in the United States and in stones and pounds and feet and inches for vignettes used in Northern Ireland and Scotland	Indicator of nutritional status (anthropometric), representing underweight, acceptable weight, overweight[37,39,40]
State of hydration	3	Does not appear dehydrated, appears dehydrated, null	Indicator of nutritional status (clinical)[37,41]
Hemoglobin, g/dL	4	8, 11, 15, 19	Indicator of nutritional status (biochemical)[37,41]
Description of amount eaten, %	5	100, 75, 50, 25, 0	Dietary indicator of nutritional status [37,41]
Affect	5	Cheerful, pleasant, depressed, confused, null	Psychological factor influencing nutrition[37,38]
Support from family and friends	3	Has help at home, does not have help at home, null	Social factors influencing nutrition[37,38]

information about gender can be randomly left out, thus creating for gender 3 levels: male, female, and null, where no information on gender is given. If using the null category, however, care must be taken to ensure that the information about the null category is not introduced or implied elsewhere. The null category thus helps add to the contextual reality of the real world, where information can sometimes be found to be missing and in the analysis helps determine what happens to a variable that is left out.

The design enables the researcher to study data nurses routinely use for decision making when providing patient care and yet control for multicollinearity of the independent variables. Age and diagnosis, for example, are sufficiently collinear to make independent assessments of nurse judgments virtually impossible to assess in actual situations. This problem is overcome in the factorial survey as the levels of the independent variables are randomly assigned. When using the factorial survey method, the levels of age and diagnosis are randomly generated. Intercorrelations among the independent variables can be tested for independence and orthogonality by examining a zero-order correlation matrix for the variables. Orthogonality is critical as it sets the design apart from correlational studies, allowing for causal relationships to be established.

Dependent variables

As with all quantitative research, the dependent variables are of primary importance. Indeed, the goal of quantitative research is to account for variance in the dependent variables. To do this, the dependent variables must be at least of interval level, and there must be sufficient variance in each dependent variable.

In factorial survey research, the investigator has the opportunity to select up to 3 dependent variables, although as few as 1 can be specified. The use of only one dependent variable puts the entire study on the back of this variable. If this dependent variable produces insufficient variance for robust analysis, the value of the study is lost. In contrast, specification of too many dependent variables runs the risk of losing the focus and attention of the respondent. Although limited examination has gone into the uppermost number of dependent variables to use in factorial survey research, it is recommended that no more than 3 dependent variables be used when examining substantive issues.[42]

A rating scale is most often used to measure the dependent variables. Both Likert-type scales and a 100-mm analogue line have been used.[14] In the 3-country study that examined nurse decision making about nutrition, the following 3 dependent variables were selected: (1) Is the patient at risk for malnutrition? (2) Should the patient be screened for malnutrition? and (3) Should the patient receive a dietary referral?

Coherent vignettes

Once the variables critical to the story are decided, it is equally important to create realistic vignettes. The vignettes should have enough information to mimic the type of information shared by nurses in reports, in charting, or in conversations about patients.

The presentation of variables in the vignette must be realistic, coherent, logical, and internally consistent. A researcher cannot logically include variables like “marital status” and “spouse’s age” as fully crossed independent variables. There is no logical age for the spouse of a single target. Moreover, the flow of the vignette is important.

Using a sequencing that keeps data of similar type together is important. Demographic data about the described patient are, for example, a logical start to vignettes. Alternatively, demographic information could be situated last in the story and the facts about the situation needing a decision could be placed first. Although beyond the scope of this article, the impact of sequencing of material in vignettes is an area that needs further research. Hennessey et al[43] recommend that pretesting may help identify problems with sequencing when highly emotional or debatable variables are used.

PRODUCING VIGNETTES

The vignettes must be generated so that all levels of each independent variable have an equal probability of being included. The critical point is that the vignettes must be generated randomly so that all levels of each independent variable have an equal probability of being included. The distinctiveness of each vignette can be achieved by several methods. Weber et al[44] wrote a computer program designed to generate vignettes that meet this criterion. However, this program has proven difficult to implement and is no longer easily attainable.

Alternatively, the vignettes can be produced by a combination of several common computer programs, that is, a spreadsheet and word processing. Zeller (unpublished data, 2003) has produced instructions for generating a random table of numbers that represent the levels of the independent variables in vignettes using MicroSoft Excel (Table 2). Once the spreadsheet is finalized, word processing is used to complete the process. The basic vignette minus the variables is word processed and then numbers that represent variables are transposed manually or with a merge function into the basic vignette structure (Table 3). Once the surveys are produced, the researchers proof all vignettes. Errors are corrected and the questionnaire is compiled. This method is time intensive, however, as it does require about 20 hours for each 1000 vignettes produced.

A more efficient method has been developed by Winchell[45] to generate random vignettes using SAS and SPSS programming. Once the levels of each independent variable have been determined (Table 1) and random assignment of values has been made according to the method described in Table 2, a vignette number is assigned to each combination of values. At this point, either an SPSS or an SAS program can be written to associate text with each value of the numeric independent variables. For example, if the independent variable *gender* takes on the values 1, 2, and 3, which represent male, female, and null, respectively, the associated text variable might be *gentext* and be assigned the values "male" when gender = 1, "female" when gender = 2, or left blank when gender = 3.

As the set of independent variables for each vignette is read from the file created according to Table 2 instructions, SPSS/SAS can write

Table 2. Generating random numbers to represent variables*

1. Open a MicroSoft Excel spreadsheet.
2. With the cursor in cell A1, type "=rand()" in the "=" box at the top of the spreadsheet. Click on another cell. This will produce a random number between 0 and 1 in cell A1.
3. Copy the random number in cell A1. Paste this value across *k* columns and down *N* rows where* *k* is 8, the number of independent variables as there are in the vignette; and *N* is 500, is the number of vignettes you wish to generate.
4. Save the file as an ".xls" file; close the file and exit from MicroSoft Excel.
5. Open SPSS. Open the "Data" file. Remember to change "Files of Type" to "Excel(*.xls)" and specify the name of the file in the box labeled "File Name."
6. Click on "Open."
7. Disable the instruction which specifies "Read Variables From the First Row of Data" and click on "OK." If things have progressed properly, you should have 8 columns labeled V1 through V8, and 500 rows of random numbers between 0 and 1 in an SPSS data file. Click on "File" and "Save As." Name the file in "File Name." Save this file as a (*.sav) file.
8. In order for V1 to have 5 levels, click on "Transform" and "Categorize Variables." Specify "5" as the number of categories. Move "V1" to the "Create Categories For" box and click on "OK." "NV1" appears in the ninth column. "NV1" has created 5 categories labeled "1," "2," "3," "4," and "5." Each category has exactly 100 of the 500 cases. Repeat this procedure for each of the 8 variables using its respective number of categories. Check to make sure that you have properly categorized each variable by clicking on "Analyze," "Descriptive Statistics," and "Frequencies." Shift all of the categorized variables into the "Variables" box and click "OK." Examination of the output should reveal the proper number of cases at each level for each independent variable.
9. Shade in and print the columns labeled "NV1" through "NV8." This printout specifies the levels of each case on each independent variable.

* This example is for producing a table that represents 8 variables and will produce 500 vignettes.

Table 3. The vignette

The patient is a ________ year old ________ (marital status) ________ (gender) who is in hospital for ________ (diagnosis). You are carrying out ________ (type of assessment). The patient is ________ (ht/wt), appears (hydration) and has a ________ (Hb). When asked about food intake the patient reports ________ (amount eaten for last 3 meals served). The patient appears ________ (affect). Has ________ (help or not).

Example of random vignettes:

Version for United Kingdom: The patient is a 65-year-old, married, male who is in hospital for congestive heart failure. You are carrying out your final nursing assessment before discharge. The patient is 5′10″ and 14 st and 6 lb, does not appear dehydrated, and has a haemoglobin of 8 g/dL. When asked about recent food intake, the patient reports eating 50% of previous 3 meals that have been served. The patient appears confused. Has help at home.

Version for the United States: The patient is a 65-year-old, married, male who is in hospital for congestive heart failure. You are carrying out your final nursing assessment before discharge. The patient is 70″ and 202 lb, does not appear dehydrated, and has hemoglobin of 8 g/dL. When asked about recent food intake, the patient reports eating 50% of previous 3 meals that have been served. The patient appears confused. Has help at home.

out a text file containing as many vignettes as required. The text values associated with the independent variables will be substituted within the skeletal paragraph (Table 3) according to the randomly assigned values of the independent variables and the dependent variables included following each scenario. This file can then be taken into MSWord, and, with minor editing, produce the vignettes for distribution. The time involved in creating the vignettes is greatly reduced.

It cannot be overstated that designing coherent vignette frameworks and then producing the vignettes themselves is often time intensive, especially if SAS/SPSS programming is not used. The result of the intense upfront work does, however, produce a survey that is often quick and easy to administer and to complete. Often, the survey requires 10 to 20 minutes to finish, depending on the number and complexity of vignettes and what other questions are asked such as demographic information.

SAMPLE SIZE AND SAMPLING

A major advantage of the factorial survey method lies in the survey aspects of the design. Besides independent patient variables, the factorial study can be used to examine a wide range of subjects for differences and similarities in judgments and decision making. Probability sampling can be used. In 1993, Ludwick[13] randomly sampled 100 nurses from the Ohio registry of licensed nurses who worked in acute care. In the exemplar study, a convenience sample of nurses and nursing students was used since it was a pilot project to test the method cross-nationally and because of limited funding. Each of 166 respondents was given 6 vignettes to rate, producing a total of 996 vignettes for analyses.

The cross-country sampling points out an advantage of the factorial survey (economy of time and money) and one of its criticisms (nonindependence of the observations). Sometimes, there are only a small number of knowledgeable respondents about the topic under consideration, or because of financial or time cost, access to subjects is limited. Limiting respondents to one vignette severely limits the power of the study to detect, describe, and infer causal effects if access to subjects is less than optimal. Despite the logistic and cost advantages of multiple vignettes per respondent, the question remains whether dependency of observations provides an erroneous analysis. At what point, however, is the number of vignettes per respondent producing a significant error term and thus producing overestimates of regression coefficients in the analysis? Critics claim that the factorial survey design is inferior to traditional survey methodology because of the alleged artificial inflation of the sample size. The artificial sample size claim comes from the contention that the unit of analysis in factorial survey research is the vignette, not the individual subject. There are multiple vignettes judged by a subject. This raises the question of how much confidence one can place in the judgments, given the proposition that each vignette is not an independent observation.

Zeller and Byers[46] respond to this assertion by suggesting that in some research projects, one may want to study only experts in an area (eg, adult protective service workers), and the available number of such individuals may be limited. Moreover, using a Monte Carlo simulation, they document that analysis will produce identical regression slopes for independent data and data that are polluted with as much as 50% of the variance in the dependent variable associated with subject dependency. Given this robustness of subject dependency, the critic's claim that such dependency undermines the credibility of the factorial survey is unfounded.[46]

DATA ANALYSIS

The statistical tool used in the analysis of factorial surveys is multiple regression. The central analysis for model building is the use of vignette variables as predictors on decision-making outcomes. The unit of analysis for the regression is the vignette, not the subject. Multiple regression provides the explained variances, effect sizes, and statistical significances that are vital to causal explanations and are not possible with ordinary survey research. The virtual uncorrelatedness of the independent variables assures that the analyst will not face the interpretational problems associated with multicollinearity. Moreover, this uncorrelatedness means that the partial regression slopes are robust.

The model handles nominal variables as well as ordinal and scale variables. When nominal variables are used, all $k - 1$ levels of each independent variable should be recoded into $k - 1$ dummy variables. All sets of dummy variables are used as predictors in a multiple regression equation predicting the outcome variable. The regression slopes produced when using all sets of dummy variables simultaneously will be approximately the same as the regression slopes produced when multiple regression analyses are conducted for each set of dummy variables representing each independent variable separately.

Using increments in the multiple correlation squared, analysts can identify the 1 or 2 independent variables that have a strong effect on the dependent variable as contrasted with the 8 or 10 independent variables that have a weak but statistically significant effect. Thus, the strong independent variables can be identified and the weak independent variables can be relegated to substantive irrelevance.

Pooling of respondents' vignettes for statistical analysis is supported in the original work of Rossi and Anderson[2(p32)] who state: "If each n respondent rates separate respondent subsamples of m factorial objects, the resulting data are $nm = N$ judgements, J_i." This analysis is possible because the subjects each rate multiple randomly produced unique vignettes. The order of production and of appearance of vignettes is random within and across individual subsamples.

If each subject is given 5 vignettes to judge, a sample of 100 would result in 500 observations. If each subject is given 30 vignettes to judge, a sample of 100 would result in 3000 observations. In the nutrition study across countries, each respondent received 6 randomly generated vignettes and 996 vignettes were used as the unit of analysis. Therefore, even with a small sample, researchers can produce a very large number of cases in a short period of time and with relative ease.

A computer software tool (such as SPSS) will produce partial regression coefficients for each level of each independent variable. Each slope assesses the extent and direction that the mean judgment of its respective category differs from the mean of the omitted category of the independent variable. The power of the entire model and the relative strength of each independent variable are evaluated by the multiple correlation squared (R^2). We note, parenthetically, that given the orthogonal generation of vignettes, the partial regression coefficients controlling for the other independent variables will be approximately equal to the regression coefficients if the other independent variables had not been controlled. Moreover, the multiple correlation squared across independent variable sets will be approximately equal to the sum of the correlations for each single independent variable set.

The analyses of the variables in this method is advantageous as many of the variables can be noncontinuous, and dummy coding can be used to estimate the effect size for levels of the nominal independent variables.[2] Specifically, the regression uses each category of independent variable minus 1 to predict the outcome measures. All but 2 of the independent variables in the cross-country study on nutrition were categorical. Therefore, dummy coding was used to estimate the effect that each category of the nominal variable had on the dependent variables. As an example, let us examine the variable of hemoglobin (or haemoglobin as used in the surveys distributed in Scotland and Northern Ireland). This variable had 4 categories (8 g/dL, 11 g/dL, 15 g/dL, and 19 g/dL). When predicting the outcome variable from hemoglobin, 3 dummy variables were created, one for 8 g/dL, 11 g/dL, and 19 g/dL, and 15 g/dL was set as the base category. When the 3 hemoglobin dummies are used as predictors of the outcome variables, the regression equation emerged as follows: $Y = a + b_1X_1 + b_2X_2 + b_3X_3$ (where a is the Y intercept, b_i are the slopes, and X_i are the hemoglobin).

Highlights from the nutrition study point up the applicability of using the factorial survey to explain which variables most strongly predict nurse judgments and decisions and to determine if there is consensus among nurses. The 3 prediction models for each of the dependent variables (predicting risk for malnutrition, the decision for the nurse to conduct a nutrition screening, and the decision to refer the patient to a dietician) were each found to explain about a quarter of the variance for each of the 3 dependent variables. Consensus was found across countries on all of these indicators.

To illustrate the power of this analysis in explaining causation, we show the model for just one of the dependent variables, nurse judgment about risk for malnutrition. Six independent patient variables accounted for 24.7% of the variance in judgment of risk. Consider the case where the levels of all independent variables were "zero." When the levels of all of the independent variables are equal to zero, the predicted outcome is simply the intercept. In this condition, a patient who ate 100% of what was served, was not underweight, was not dehydrated, did not have a low hemoglobin, was not confused, and did not have a diagnosis of congestive heart failure, the predicted risk level for such a condition was 4.160. In formula form, the equation for this regression model appears as follows: Risk $= 4.160 + (0)(0.573) + (0)(0.750) + (0)(0.0846) + (0)(0.756) - (0)(0.451) + (0)(0.930) = 4.160$. Alternatively, now consider the above case with the single exception in level of independent variable that the patient ate 0% of what was served instead of 100% of what was served. In this case, the risk level was 6.452. In formula form: Risk $= 4.160 + (4)(0.573) + (0)(0.750) + (0)(0.846) + (0)(0.756) - (0)(0.451) + (0)(0.930) = 6.452$. All slopes in this regression equation are $P < .01$.

For each reduction of 25% of the amount of food that the patient ate, the perceived risk level was increased by .573, dehydration increased the predicted risk level by .750, a low hemoglobin increased the predicted risk level by .846, presence of confusion increased the predicted risk level by .756, a diagnosis of congestive heart failure decreased the predicted risk level by .451, and being underweight increased the predicted risk level by .930. The risk level for a patient who ate 0% of his food is increased by 2.292 (.573 per 25% reduction times 4 decreases of 25% = 2.292). From this, the predicted risk level for a patient who ate no food, was underweight, was dehydrated, had a low hemoglobin, was confused, and had a diagnosis of congestive heart failure was 8.024.

In addition to the requisite analysis of the regression slopes and their significance, we additionally examined squared correlation of each randomly assigned independent variable with each outcome. This produces a percentage to examine the relative impact of the significant variables beyond the customary standardized regression (β) values. This analysis step is of particular value since large survey data can produce statistically significant but substantially meaningless results. Such results have little predictive power and no theoretical meaning, but show statistical significance at the predetermined *P* value. For example, in a study of 100 cases, 4% of the variance is expected to be statistically significant.

In the squared correlations examined here for demonstration purposes, our findings showed that the dependent outcomes were significantly influenced by 6 of the patient variables: amount (percentage of food eaten), height/weight, state of hydration, hemoglobin, affect (confusion), and diagnosis (congestive heart failure). These were significant predictors in all the regression models. The strongest independent variable to influence the outcomes was the reported percentage of food eaten by the patient. The less the patient reported eating over the last 3 meals, the more likely the subjects were to identify risk for malnutrition. This variable, called amount, accounted for 13.5% of the variance in risk regression model. This explained variance is comparable to a correlation coefficient of .367. Although the substantive findings related to nutrition are not in themselves relevant here, the variance that is represented by 13.5% clearly demonstrates the power of the factorial design in identifying causal analysis without issues of multicollinearity. We found that nurses in 3 countries all agreed that the amount the patient "reported" eating was clearly the most important variable for determining risk for malnutrition. In fact, the variable that next best explained judgment was the anthropometric measure of height:weight ratio, which explained about 4% of the variance.

CONCLUSION

Nurses can use the factorial survey to gain the strengths of survey research and the robustness of the experiment from factorial designs. The factorial survey can be used across settings (eg, types of units and hospitals), across practices (eg, emergency department nurses and surgical nurses), and across countries. Other research designs in nursing often present with 3 major problems. First, clinical problems occur in the "real world" and, therefore, any study of these problems must allow for the contextual complexity experienced by professionals. Issues of whether or how social and psychological characteristics of the person judged, work-setting factors, or the clinician's background influence judgments are difficult to disentangle. Second, gaining cooperation of professionals as research subjects is difficult if scenarios to be judged are lengthy, when observers monitor professionals making judgments, if lengthy descriptions of how decisions are made are required, or if confidentiality is an issue. When professionals are solicited to participate, the researcher often limits the range of vignette variables. Thus, the responses to the vignettes are restricted. Third, confounding real-world variables such as race, age, and education are often difficult to separate. In traditional experimental designs, a limited number of variables with few levels are used to create orthogonality so that oversimplification results and real-world complexity is sacrificed.

The factorial survey is a design that helps to minimize these 3 problems. It combines the advantages of the multivariate experiment with the realism and wide dissemination potential of surveys, thus providing more of the detail that characterizes real-life situations.[2] First, the survey design allows the researcher to sample numerous 10 to 15 situation-based variables that can mimic the type of information nurses regularly encounter in reports, case studies, conversations, and documentation. Second, gaining cooperation is relatively easy as completing the vignettes often takes 10 to 20 minutes. Third, the factorial design permits the researcher the opportunity to disentangle confounding variables as factor orthogonality can be assured and thus the regression analysis can distinguish the separate impact of each independent patient variable in the vignette.

Nurse researchers have an opportunity to develop, test, adapt, and move forward factorial survey research in areas that have important implications for clinical judgments and decision making within nursing and healthcare and moreover to contribute to methodology and analysis issues that cut across disciplines. Nurses can aid in the development of factorial survey methods, a design that was originally developed for examining issues of social stratification.[2] Nurse researchers can test the method in substantive clinical areas that require judgments and/or decisions for substantive issues that are often difficult to measure because of cost, ethical, or time constraints.[42] Nurse errors, patient safety, abuse, end-of-life decisions, healthcare treatment, and access options are just some examples of problems that would reveal ". . . the shared and idiosyncratic principles of judgments . . ."[47(p10)] that would move the method forward. Nurses are in a unique position to study substantive health issues across settings, roles, cultures, disciplines, providers, care recipients, and both care recipients and providers or any other combination of these variables. In an era where cost containment, international and/or interdisciplinary collaborative research, and outcomes are increasingly emphasized, the factorial design can be used for a variety of projects from pilot work to studies involving large sample populations. There are a variety of ways that nurses could use the factorial survey method. Three areas highlighted here are methods, concept definition, and education or program evaluation.

Methods' issues like the presentation order of variables or the maximum number of variables in a study can be examined within the context of significant health concerns like end-of-life judgments and decisions. End-of-life decisions could be studied for differences among nurses, patients, and families. Can patients handle less information than do nurses? Does the order of information presented change the decision of families?

Definitions among poorly differentiated concepts such as abuse, neglect, and self-neglect could be evaluated by examining which variables are critical in differentiating nurse judgments in these 3 areas. Further, various providers could evaluate these concepts across settings. Emergency department nurses and physicians and providers in primary care such as physicians and nurse practitioners could be compared for similarities and differences in judgments and decisions.

Finally, program or educational interventions could be tested using the factorial survey. Instead of knowledge questionnaires and satisfaction surveys, the power of the factorial design could be brought to bear to examine judgments and decisions post intervention. This could be done using a pre-post design method or by comparison with a control group.

Factorial surveys are not without their own limitations. An obvious one is that the results obtained with factorial design are hypothetical as with any use of vignettes. What someone reports they would do in a situation and what they actually do in that situation may differ. Protections can be taken so that the vignette is made as realistic as possible so that it accurately portrays the important characteristics of the situation under investigation. While contextual complexity of the real world is difficult to translate into a short story, nurses frequently make judgments and decisions on "stories" given in reports and documented in charts on a daily basis. Yet this topic of vignette validity is also an area for further research and development by nurses.

Some research has been conducted in this area[13] (O'Toole et al, unpublished data, 1993). In addition to obtaining data on the vignettes, these authors obtained data on the "most recent case" of the problem that was being studied, acute patient confusion and child abuse. Their analysis of these data revealed that the data presented in the vignettes and the nurse responses were similar to nurse experiences. The validity of the factorial survey was enhanced by this design addition and subsequent analysis. The outcomes used in a factorial survey are more credible when respondents identify criteria similar to those found in the vignettes. If, however, themes emerge from the data that were not included in the vignette, then these themes can be evaluated for replication and extension of the vignette in subsequent research efforts. In spite of this limitation, it is important to reiterate that the factorial survey method overcomes multicollinearity and provides an experimental design that one cannot get in an ideal real-world situation.

To end with, it is of particular value to note that this exemplar on nurses' nutritional decision making illustrates the relative ease with which it was possible to carry out cross-cultural research using factorial surveys. Respondents were students in broadly similar nurse education programs, studying nutrition at similar stages in the curriculum. The only differences necessary in the questionnaires related to spelling and units of measurement. Hemoglobin spelling was varied as "hemoglobin" and "haemoglobin." Weight was measured in pounds for US respondents and stones and pounds in the UK questionnaires. Thus, with minimal adaptation, the questionnaire, including the vignettes, was suitable for use in either country, making it possible to examine decision making across countries in the same study and avoiding the need for separate or follow-up studies.

In summary, factorial surveys present a powerful research design that can economically produce data relevant to important research questions that practitioners and researchers in nursing wish to examine. In many circumstances, analyses from these data provide insights that the researcher simply would not, could not, or should not be able to obtain using other research designs.

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