Journal of Occupational Health Psychology
2000, Vol. 5, No. 1, 127–141

1076-8998/00/$5.00 DOI: 10.1037//1076-8998.5.1.127

Behavioral–Diagnostic Analysis of Compliance With Universal Precautions Among Nurses

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This study used the PRECEDE model (L. W. Green, M. W. Kreuter, S. G. Deeds, & K. B. Partridge, 1980) to examine individual, job–task, and environmental–organizational factors related to compliance with universal precautions (UP) among nurses. Structural equation modeling showed that the hypothesized model did a better job predicting general compliance ($R^2 = .41$) than compliance with personal protective equipment (PPE; $R^2 = .18$). All 3 categories of diagnostic factors (predisposing, enabling, and reinforcing) influenced general compliance, but predisposing factors were relatively unimportant for compliance with PPE. With a set of nested models, the greatest improvement in model fit occurred when the indirect effects of reinforcing factors were added. A positive safety climate may increase the likelihood that the work environment will contain features that enable workers to comply with safe work practices.

Universal precautions (UP) are recommended work practices designed to protect health care workers (HCWs) from exposure to blood-borne pathogens. In essence, HCWs should assume that all patients are infectious for the human immunodeficiency virus (HIV), hepatitis B virus (HBV), or other blood-borne pathogens. Specific precautions include proper disposal of needles and other sharps, not recapping used needles, and using disposable latex gloves and other protective garments and equipment. The Centers for Disease Control and Prevention (CDC) issued formal guidelines related to UP in 1987 (CDC, 1987), and UP became mandatory in 1991 with the passage of the Occupational Safety and Health Administration (OSHA) Blood-Borne Pathogens Standard (OSHA, 1991). The OSHA standard requires employers to establish, among other things, an exposure control plan and to offer training to workers.

Despite these actions, a number of studies conducted both before and after the enactment of the OSHA standard indicate that compliance with UP is frequently quite poor (Gershon, Karkashian, & Felknor, 1994). For example, Kelen and colleagues (Kelen et al., 1990) found only 44% adherence to UP in an observational study conducted in the emergency room at Johns Hopkins University Medical Center in Baltimore, Maryland. Hammond and colleagues (Hammond, Eckes, Gomez, & Cunningham, 1990) reported that among house officers only 16% strictly adhered to UP guidelines. Becker and colleagues (Becker et al., 1990) found that the rate of recapping in four large medical centers was greater than 25% during all measurement periods and higher than 50% in some instances. A national survey of over 3,000 HCWs (Hersey & Martin, 1994) found that only 43% of patient care staff "always" wore gloves to draw blood and only 63% "always" washed their hands after removing their gloves. Rates of compliance for outer garments, masks, and protective eyewear were even lower. A recent study of 6,000 Danish physicians showed the following compliance rates (during preceding week) for surgeons and pathologists: 63% for gloves, 55% for masks, and 11.5% for protective eyewear. Compliance rates for "nonoperative" catego-

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This work was supported in part by the Centers for Disease Control (CDC) and NIOSH. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the CDC or NIOSH.

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ries of physicians were much lower for each of these behaviors (Nelsing, Nielsen, & Nielsen, 1997).

The recently and widely publicized death of a worker at the Yerkes Primate Center who did not use appropriate eye protection has essentially brought the whole issue of compliance into national and international prominence (Lore, 1998). However, noncompliance with UP is a broad-based occupational health problem for HCWs. The risk of HIV infection has been estimated at about 0.3% following percutaneous exposure to HIV-contaminated blood (Ippolito, Puro, & DeCarli, 1993; Marcus et al., 1993; Tokars et al., 1993). The cumulative lifetime risk of infection for certain high-risk subgroups of HCWs, such as emergency medical service personnel, surgeons, and trauma teams, may be as high as 1% to 2% (Lowenfels, 1989; Parker, 1992; Wears, 1991). CDC surveillance reports indicate that 54 HCWs in the United States have been documented as having seroconverted to HIV following occupational exposures. The CDC is aware of 132 other cases of HIV/AIDS among HCWs who have not reported other risk factors and who report a history of occupational exposure to potentially contaminated materials (CDC, 1997). The risk of HBV infection after exposure is much greater, ranging from 6% to 30% (CDC, 1985). Approximately 2,500–5,000 acute cases of HBV infection are reported among HCWs each year, resulting in an estimated 400 hospitalizations and 250 fatalities (CDC, 1989; Grady et al., 1978).

Although the compliance problem is well documented, relatively little is known about why HCWs fail to follow UP recommendations. Surveys of HCWs suggest that many HCWs view UP as adversely affecting job performance and the patient–practitioner relationship (e.g., Kelen et al., 1990; Linn, Kahn, & Leake, 1990; Nelsing et al., 1997; Willy, Dhillon, Loewen, Wesley, & Henderson, 1990). Lack of knowledge about modes of occupational transmission and UP procedures has also been implicated (e.g., Becker et al., 1990; Kelen et al., 1990; Willy et al., 1990), but recent studies have shown improvements in both information dissemination and knowledge levels (e.g., Gershon et al., 1995; Hersey & Martin, 1994). In addition, HCWs do not appear to dismiss or underestimate their personal risk of occupationally related infection (e.g., Becker et al., 1990; Cooke, 1988; Hoffman-Terry, Rhodes, & Reed, 1992). In fact, HCWs are more likely to overestimate their level of occupational risk. Most HCWs also possess a reasonable amount of confidence in the effectiveness of UP as a preventive measure (e.g., Becker et al., 1990; Hoffman-Terry et al., 1992; Kelen et al., 1990).

Somewhat surprisingly, there has been virtually no detailed consideration of the role of organizational and environmental factors in noncompliance (DeJoy, Gershon, Murphy, & Wilson, 1996). Environmental and organizational factors include organizational UP policies and management attitudes toward HIV/AIDS and UP, availability of personal protective equipment (PPE) in the work area, and provision of employee feedback and reinforcement with respect to compliance with UP requirements. Prior studies in other areas of occupational safety and health are quite consistent in showing that environmental and organizational factors are important predictors of employee work behavior (e.g., Hofmann, Jacobs, & Landy, 1995; Lindell, 1994; Shannon, Mayr, & Haines, 1997; Sheehy & Chapman, 1987). The potential importance of such factors has been discussed with respect to health care in general (Cox & Leiter, 1992) and UP in particular (White & Berger, 1992), but these factors have not been addressed in empirical research.

The present research used the PRECEDE model (Green & Kreuter, 1991; Green, Kreuter, Deeds, & Partridge, 1980) to structure a broad-based examination of individual, job–task, and environmental–organizational factors related to compliance with UP. PRECEDE stands for Predisposing, Reinforcing, and Enabling Causes in Educational Diagnosis and Evaluation. This model was developed originally as a planning framework for health education programs, but the basic PRECEDE framework has been adapted for application to self-protective behavior at work (Dedobbeleer & German, 1987; DeJoy, 1986; Peters, 1991).

The PRECEDE model emphasizes the identification of the behavioral causes of health problems and the analysis of factors related to these causes. Three sets of diagnostic factors drive the development of intervention strategies (see Figure 1). Predisposing factors are the characteristics of the individual (beliefs, attitudes, values, etc.) that facilitate or hinder self-protective behavior; they are conceptualized as providing the motivation for self-protective behavior. Enabling factors refer to objective aspects of the environment or system that block or promote self-protective action. The skill and knowledge needed to follow prescribed actions would be included here, as would the availability and accessibility of protective equipment and other resources. Most barriers and costs associated with compliance would be classified as enabling factors. Reinforcing factors involve any reward or punishment that follows or is

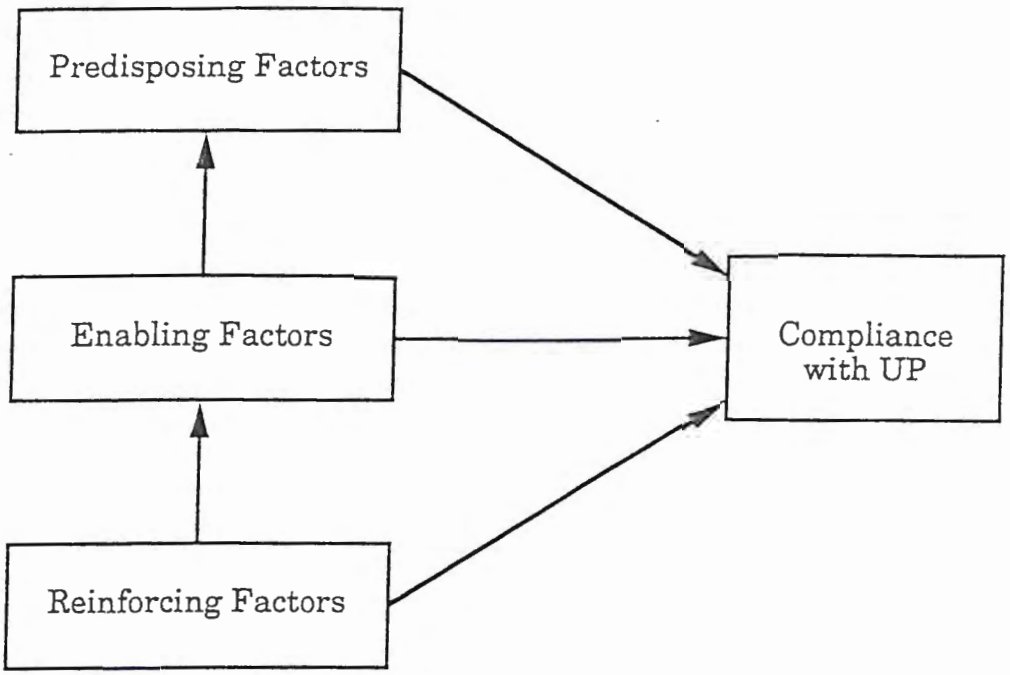

Figure 1. Principal hypothesized relationships among the three diagnostic factors in the PRECEDE model. UP = universal precautions.

anticipated as a consequence of behavior. Performance feedback; the social approval or disapproval received from coworkers, supervisors, and managers; and other safety climate dimensions involving behavior-outcome expectations would typically be classified as reinforcing factors in workplace settings (Dedobbeleer & German, 1987; DeJoy et al., 1996). In contrast to more traditional perspectives on workplace self-protective behavior, the PRECEDE model goes beyond individual-level variables and assigns considerable importance to social–environmental factors or the context within which the behavior occurs (DeJoy, 1996; Sheehy & Chapman, 1987; Smith & Beringer, 1987).

Structural modeling techniques were used to examine the contribution of the three sets of diagnostic factors to compliance with UP. A combination of exploratory and confirmatory methods were used to form the measurement models for the three categories of diagnostic factors and compliance (Anderson & Gerbing, 1988). These individual models were evaluated prior to analyzing the full measurement model. Next, the complete structural model of interest, as portrayed in Figure 1, was evaluated. Finally, a series of nested models were used to explore the linkage between reinforcing and enabling factors. Although not emphasized in the original PRECEDE model (Green et al., 1980), this linkage may be quite important to workplace self-protective behavior, especially in view of the current interest in safety climate (e.g., Cox & Leiter, 1992; DeJoy, 1996; DeJoy et al., 1996; DeJoy, Murphy, & Gershon, 1995; White & Berger, 1992). In essence, a positive safety climate may help to create work environments that enable self-protective action by workers.

Method

Research Context

This research was conducted as part of a National Institute for Occupational Safety and Health/Educational Resource Center, Inc. project to survey hospital-based and other HCWs (dentists, embalmers, etc.) concerning factors related to compliance with UP requirements. The hospital-based sample consisted of 1,716 HCWs employed by three large (approximately 1,000 beds), regionally distinct, acute-care hospitals. The three largest occupational groups represented were nurses (n = 902), physicians (n = 322), and technicians (n = 247). The sample for the present study consisted of the 902 nurses at the three sites.

Questionnaire Development

The Health Care Worker Questionnaire designed for this project contained items and scales measuring a wide variety of individual, psychosocial, job–task, and organizational

factors. A general overview of questionnaire and scale development for the hospital-based sample can be found in Gershon et al. (1995). Guidance for selecting specific items and scales and for categorizing them as predisposing, enabling, or reinforcing factors came from the original work of Green and colleagues (Green et al., 1980; Green & Kreuter, 1991) as well as previous applications of the PRECEDE framework to workplace self-protective behavior (e.g., Dedobbeleer & German, 1987; DeJoy, 1986; Peters, 1991). Preliminary analyses of the data from 482 nurses at one of the centers (DeJoy et al., 1995) also facilitated item and scale selection for the present study. The items and scales that were used to represent the major components of the PRECEDE model are summarized below.[1] Unless otherwise noted, all response scales were 4- or 5-point Likert scales (e.g., *strongly agree* to *strongly disagree*). Responses were reverse scored as necessary so that the direction of responses to multi-item scales was consistent. Prior to conducting the confirmatory factor analyses and structural equation models, we formed item composites when possible to improve the reliability of the observed variables, as well as to produce more normally distributed variables. An attempt was made to form at least three and preferably four composites to measure each latent factor. A minimum of two indicators is required for identification when more than one factor is present; however, three to four indicators are recommended as a means to avoid problems with identification, negative variance estimates, and nonconvergence (e.g., Bollen, 1989).

Predisposing Factors

Six different sets of items were identified as being part of predisposing factors: Effectiveness of Preventive Actions, Attitudes Toward Patients With HIV, Risk-Taking Tendencies, General Knowledge of HIV, Knowledge of HIV Transmission in Health Care, and Knowledge of Alternative Modes of HIV Transmission. Effectiveness of Preventive Actions was composed of three items (e.g., "I can reduce my occupational risk of HIV infection by complying with UP"). Attitudes Toward Patients With HIV consisted of an 11-item scale adapted from Shrum, Turner, and Bruce (1989). This scale included items such as "HCWs should be made aware of the HIV status of all patients" and "Our profession has a responsibility to treat patients with AIDS." The third construct, Risk-Taking Tendencies, was composed of 6 items from Zuckerman's Sensation Seeking Scale (Zuckerman, 1979). Sample items included "I prefer an exciting, unpredictable life" and "I do dangerous things sometimes just for the thrill of it." The three remaining predisposing factors accessed general knowledge of HIV and the transmission of blood-borne pathogens. Most of these questions were taken from the AIDS Awareness Test (National Center for Health Statistics, 1988). General Knowledge of HIV was measured by 5 items (e.g., "AIDS is a disease caused by a virus"). Knowledge of Alternative Modes of Transmission included 7 items such as "A person can be infected with HIV by eating food that was prepared by someone infected with HIV." The final predisposing factor consisted of 8 items measuring Knowledge of Transmission in Health Care (e.g., "HIV may be transmitted to hospital workers by touching the skin of an HIV-infected person without wearing gloves").

Enabling Factors

Scales measuring five different enabling factors were used: Availability of PPE, Job Hindrances, Workload, Training in UP, and Training in the Use of PPE. Availability of PPE was composed of five items (e.g., "All of the necessary equipment and devices to help me avoid contact with HIV are readily available"). Job Hindrances was measured by four items, such as the following: "My job duties often interfere with my being able to comply with UP." Eight items adapted from Caplan and colleagues (Caplan, Cobb, French, Harrison, & Pinneau, 1975) were used to measure Workload. Two types of training were assessed: Training in UP and Training in the Use of PPE. Within the PRECEDE model, new knowledge and skills, such as that afforded by specific training activities, are generally classified as enabling factors (Green & Kreuter, 1991). Both types of training were measured by single items and were treated as observed variables in the factor model (i.e., measured with no error).

Reinforcing Factors

Reinforcing factors consisted of safety climate and prior exposure to blood or other potentially contaminated materials. A total of 17 items from the questionnaire were identified as measuring various aspects of safety climate. For the present purpose, *safety climate* was defined as the perceptions that workers share about safety in their organization (Zohar, 1980). In addition, *exposure* was defined as the number of times a person had been exposed to blood or other body fluid at work.

Compliance With UP

A total of 11 items measured various aspects of compliance behavior, including behaviors such as sharps disposal, hand washing, needle recapping, and wearing of protective outer garments.

Sample Selection and Questionnaire Administration

Confidential, self-administered questionnaires were sent to 3,000 HCWs at three large acute-care hospitals in different regions of the United States. Extensive follow-up procedures were used to improve the overall response rate, and a total of 1,716 usable questionnaires were obtained, representing an overall response rate of 57%. Nurses represented the single largest occupational group and were the sample for this study. Of the 902 responses from nurses, 482 were obtained from Medical Center 1 (Mid-Atlantic), 304 were obtained from Medical Center 2 (Midwest), and 116 were obtained from Medical Center 3 (Southwest). The response rates for nurses at the three sites were 54%, 87%, and 33%, respectively. The majority of the nurses were

[1] For the sake of brevity, only sample questions for each measure are included in the text. Copies of the complete questionnaire used in this study may be obtained from David M. DeJoy.

female (93%), and the mean age was 35.24 years (SD = 8.34). Of the 902 responses to the questionnaire, only 13 contained substantial missing data (10 or more) on the variables used in this study. These individuals were removed from analyses. For the remainder of the sample (n = 889), data imputation, using the hot deck approach, was performed to eliminate missing data (Roth, 1994).

Data Analyses

Confirmatory factor analyses and structural equation modeling were conducted using the software LISREL 8 with maximum likelihood estimation (Joreskog & Sorbom, 1993). To evaluate the overall model fit, we used the following indexes: chi-square, goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), the nonnormed fit index (NNFI), and the root mean square error of approximation (RMSEA). GFI, AGFI, and NNFI values of .90 and above are considered a reasonable minimum fit for model acceptance (Hoyle & Panter, 1995), whereas RMSEA values between .03 and .08 are interpreted as reasonable (Browne & Cudeck, 1993).

Results

Tables 1 and 2 contain the reliability coefficients and descriptive statistics for the final predisposing and enabling variables, respectively. Before summarizing the distributional characteristics of the reinforcing and compliance variables, we took the following additional steps.

Maximum likelihood exploratory factor analysis with oblique rotation was used to evaluate plausible safety climate factor structures. A four-factor solution was selected as the best representation of the 17 items measuring safety climate and included the following factors: Priority Assigned to Safety, Formal Feedback, Informal Feedback, and Management Actions/Commitment to Safety. Priority Assigned to Safety was measured with 4 single items (e.g., "In my organization, there are no significant compromises or shortcuts taken when worker protection from infectious diseases is at stake"). Formal Feedback contained 4 items (e.g., "Where I work, unsafe work practices are corrected by supervisors"). Informal Feedback was also measured by 4 items (e.g., "Employees in my workgroup remind each other of the need to follow UP"). Management Actions/Commitment to Safety was measured by 5 items (e.g., "Where I work, top-level management gets personally involved in safety activities"). In addition, because interest in exposure was in the total amount rather than specific types of exposure (e.g., number of needle stick injuries), a composite of the four types of exposure (needle sticks, contacts with open wounds,

Table 1
Descriptive Statistics for Predisposing Factors

Variable (V)	No. of items	M	SD	Skew	Kurtosis
Effectiveness of preventive actions (.60)					
V1	1	3.69	0.56	−2.16	6.07
V2	1	3.53	0.62	−1.27	1.89
V3	1	3.09	0.70	−0.69	0.89
Attitudes toward HIV patients (.75)					
V4	2	7.61	1.44	−0.23	−0.33
V5	3	10.79	2.18	−0.19	0.08
V6	3	12.01	2.17	−0.53	−0.10
V7	3	9.61	2.05	0.19	0.02
Risk-taking tendencies (.72)					
V8	2	4.23	1.16	0.15	0.21
V9	2	3.67	0.96	0.23	0.30
V10	2	4.69	1.21	0.33	0.20
General knowledge of HIV (.57)					
V11	3	1.92	0.46	−1.78	6.97
V12	2	1.86	0.41	−2.96	8.34
Knowledge of alternative modes of transmission (.82)					
V13	3	2.50	0.94	−1.68	1.40
V14	2	1.09	0.79	−0.17	−1.38
V15	2	1.55	0.71	−1.25	0.09
Knowledge transmission in health care (.84)					
V16	3	1.98	0.99	−0.58	−0.77
V17	3	2.06	1.10	−0.84	−0.71
V18	2	1.23	0.83	−0.46	−1.40

Note. Reliability coefficients (Cronbach's α) are in parentheses.

Table 2
Descriptive Statistics for Enabling Factors

Variable (V)	No. of items	*M*	*SD*	Skew	Kurtosis
PPE (.84)					
V19	1	3.24	0.72	−0.69	0.18
V20	2	6.64	1.10	−0.50	0.33
V21	2	6.98	1.04	−0.58	−0.60
Job hindrances (.73)					
V22	2	3.51	1.16	0.50	0.20
V23	2	3.33	1.02	0.37	−0.06
Workload (.70)					
V24	3	5.02	1.24	−0.13	−0.36
V25	3	4.58	1.36	0.02	−0.44
V26	2	5.17	1.01	−0.09	−0.33
Training in UP (within last 6 months)					
V27	1	1.83	0.61	0.44	1.04
Training in PPE					
V28	1	3.28	0.61	−0.54	0.90

Note. Reliability coefficients (Cronbach's α) are in parentheses. PPE = personal protective equipment; UP = universal precautions.

splashes to eyes or mouth, and cuts with sharp objects) was formed. Table 3 contains the reliability coefficients and descriptive statistics for the final reinforcing variables.

Maximum likelihood exploratory factor analysis with oblique rotation was also used to evaluate plausible factor structures for compliance. Ratings for these items were along a 4-point scale (4 = *always*, 3 = *often*, 2 = *sometimes*, 1 = *rarely/never*). The percentage of nurses who said they "always" or "often" performed the various behaviors differed considerably across the 11 items. Compliance rates were quite high (90%) for 5 of the items (sharps disposal, hand washing, glove usage, waste disposal, and handling scalpels), moderately high (70% to 80%) for 3 others (needle recapping, cleaning up

Table 3
Descriptive Statistics for Reinforcing Factors

Variable (V)	No. of items	*M*	*SD*	Skew	Kurtosis
Priority assigned to safety (.82)					
V29	1	3.08	0.70	−0.49	0.32
V30	1	3.16	0.63	−0.54	1.06
V31	1	2.95	0.76	−0.43	−0.05
V32	1	3.03	0.65	−0.54	1.06
Formal feedback (.69)					
V33	1	3.33	0.64	−0.51	−0.29
V34	1	4.28	0.75	−0.82	0.25
V35	1	3.59	0.55	−1.15	1.44
V36	1	2.80	0.84	−0.11	−0.77
Informal feedback (.75)					
V37	1	2.90	0.63	−0.42	0.76
V38	1	3.07	0.71	−0.39	−0.09
V39	1	2.63	0.75	0.09	−0.45
V40	1	2.59	0.70	0.10	−0.31
Management actions/commitment to safety (.74)					
V41	1	2.46	0.84	−0.04	−0.61
V42	1	2.77	0.70	−0.31	0.08
V43	1	3.12	0.61	−0.57	1.59
V44	1	3.12	0.65	−0.54	0.94
V45	1	2.59	0.84	−0.19	−0.55
Prior exposures					
V46	4	0.57	1.01	2.19	5.47

Note. Reliability coefficients (Cronbach's α) are in parentheses.

Table 4
Descriptive Statistics for Compliance Factors

Variable (V)	No. of items	*M*	*SD*	Skew	Kurtosis
Compliance with PPE (.73)					
V47	1	3.60	1.12	−0.54	−0.45
V48	1	3.75	1.25	−0.70	−0.60
V49	1	3.53	1.25	−0.47	−0.82
General compliance (.53)					
V50	3	11.44	1.50	−0.77	−0.14
V51	3	12.21	1.50	0.77	−0.14
V52	2	13.08	1.15	−1.15	0.53

Note. Reliability coefficients (Cronbach's α) are in parentheses. PPE = personal protective equipment.

spills, eating and drinking in work area), and quite low (50% to 60%) for the remaining 3 items (protective outer garments, eye shields, and face masks). Other researchers have also reported relatively poorer compliance rates for these last three barrier-related methods (e.g., Hersey & Martin, 1994; Nelsing et al., 1997; Roy & Robillard, 1994). Exploratory factor analyses yielded a two-factor solution: the first factor contained the 8 items showing either high or moderate levels of compliance, whereas the second factor contained the 3 items with the poorest levels of compliance (see Table 4).

Measurement Models

Confirmatory factor analyses were conducted on each of the predisposing, enabling, reinforcing, and compliance factors. Table 5 shows the intercorrelations among the 18 predisposing, enabling, reinforcing, and compliance factors. Table 6 summarizes the goodness-of-fit statistics for each individual model and for the full measurement model. The overall chi-square statistics show that each of these models could be rejected on a statistical basis; however, in each instance, the other goodness-of-fit statistics were within acceptable ranges. In general, the models for predisposing and enabling factors displayed better overall fit than the models for reinforcing factors and compliance.

Structural Model

The hypothesized model shown in Figure 1 includes the direct effects of predisposing factors, as well as the direct and indirect effects of both enabling and reinforcing factors on compliance. Green and Kreuter (1991) argued that in some instances, predisposing factors (beliefs, attitudes, values, etc.) may be sufficient to prompt self-protective action; however, the more likely situation is that enabling (resources, skills, etc.) and reinforcing (safety climate, etc.) factors contribute to and allow this initial motivation to be realized. Table 7 contains the goodness-of-fit statistics for the full structural model.[2] The chi-square for the hypothesized full model could be statistically rejected, but the other fit indexes showed acceptable levels of fit. The R^2 values for this full model were .18 for compliance with PPE and .41 for general compliance.

Table 8 contains the regression coefficients for compliance regressed on each of the three diagnostic factors. As can be seen in Table 8, no predisposing factors significantly predicted compliance with PPE; however, three predisposing factors predicted general compliance. General compliance was better among those who had more positive attitudes toward patients with HIV, displayed lower risk-taking tendencies, and were better informed about modes of transmission in health care. Two enabling factors were significantly related to compliance with PPE: greater availability of PPE and having fewer job hindrances. Having fewer job hindrances was also a significant predictor for general compliance. Among the reinforcing factors, three factors predicted compliance with PPE: priority assigned to safety, formal feedback, and informal feedback. The coefficients for the first two of these factors were negative, indicating that compliance was actually poorer when a higher priority was assigned to safety and when more formal feedback on safety performance was provided. In contrast, receiving greater informal feedback was associated with better compliance with PPE. A similar effect for informal feedback was also evident for general compliance. In addition, greater prior exposure to potentially contaminated materials predicted poorer general compliance.

[2] A summary of factor loadings, unique variances, and the variance–covariance matrix of observed variables for the full structural model can be obtained from David M. DeJoy.

Table 5
Intercorrelations Among Predisposing, Enabling, Reinforcing, and Compliance Factors

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Effectiveness of preventive actions	—																	
2. Attitudes toward HIV patients	.31	—																
3. Risk-seeking tendencies	−.03	.14	—															
4. General knowledge of HIV	.20	.24	−.10	—														
5. Knowledge of alternative modes of transmission	.24	.33	.09	.36	—													
6. Knowledge of transmission in health care	.33	.01	−.12	.14	−.01	—												
7. Availability of PPE	.35	.26	−.09	.21	.17	.25	—											
8. Job hindrances	−.44	−.32	.14	−.20	−.22	−.24	−.33	—										
9. Workload	.06	.05	−.09	.11	.01	.22	.13	−.05	—									
10. Training in UP	.08	.06	.03	−.11	−.06	.05	.12	−.11	−.08	—								
11. Training in PPE	.38	.20	−.02	.09	.12	.23	.38	−.37	.08	.18	—							
12. Priority assigned to safety	.33	.22	−.06	.12	.13	.19	.55	−.46	−.01	.26	.47	—						
13. Formal feedback	.32	.22	−.07	.12	.12	.22	.49	−.48	.15	.30	.46	.61	—					
14. Informal feedback	.25	.16	−.04	.08	.08	.16	.37	−.35	.10	.32	.39	.66	.72	—				
15. Management actions	.31	.20	−.05	.10	.12	.19	.48	−.41	.02	.28	.53	.85	.63	.75	—			
16. Prior exposures	−.10	−.08	.03	−.05	−.06	−.04	−.18	.21	.09	−.03	−.01	−.15	−.12	−.14	−.11	—		
17. Compliance with PPE	.16	.08	−.09	.04	.01	.13	.20	−.25	.06	.13	.15	.18	.20	.33	.25	−.09	—	
18. General compliance	.28	.25	−.20	.13	.14	.26	.33	−.51	.08	.15	.27	.46	.37	.43	.45	−.23	.50	—

Note. PPE = personal protective equipment; UP = universal precautions.

Table 6
Goodness-of-Fit Statistics for the Measurement Models

Model	*df*	χ^2	GFI	AGFI	NNFI	RMSEA
Predisposing	120	254.92**	.97	.96	.96	.036
Enabling	27	50.83**	.99	.98	.99	.031
Reinforcing	126	605.16**	.93	.91	.89	.065
Compliance	8	48.60**	.98	.95	.92	.076
Full model	1,131	2,317.82**	.90	.89	.91	.034

Note. GFI = goodness-of-fit index; AGFI = adjusted goodness-of-fit index; NNFI = nonnormed fit index; RMSEA = root mean square error of approximation.
** $p < .01$.

Table 9 shows the regression coefficients for predisposing factors regressed on each of the five enabling factors. The availability of PPE and job hindrances were predictive of virtually all of the predisposing factors. Greater availability of PPE was related to stronger beliefs in the effectiveness of preventive actions, more positive attitudes toward HIV patients, and greater UP-related knowledge in each of the three areas measured (general knowledge of HIV, knowledge of alternative modes of transmissions, and knowledge of transmission in health care). Job hindrances were associated with each of the six predisposing factors in the expected direction, that is, fewer job hindrances predicted stronger beliefs in the effectiveness of preventive actions, more positive attitudes, diminished risk-seeking tendencies, and greater levels of each of the three categories of knowledge about HIV and its transmission. There were several additional significant coefficients. Higher workload predicted greater knowledge of transmission in health care, but on the other hand, training in UP predicted less general knowledge of HIV and diminished knowledge of alternative modes of transmission. Training in PPE predicted greater confidence in the effectiveness of preventive action and better knowledge of transmission in health care.

Table 10 summarizes the effects of reinforcing factors on enabling factors. Greater priority assigned to safety predicted greater availability of PPE and fewer job hindrances. Higher levels of formal feedback also predicted fewer job hindrances but less availability of PPE and less recent training in PPE. There was also a significant coefficient for workload, indicating that receiving more formal feedback was associated with greater workload. Receiving more informal feedback was also associated with less availability of PPE and more training in overall UP. Higher levels of management actions and commitment were associated with less recent training in PPE. Finally, greater numbers of prior occupational exposures to blood and other potentially contaminated materials were associated with less availability of PPE and more job hindrances.

Nested Models

A series of nested models was analyzed to explore the direct versus the indirect effects of reinforcing factors on compliance with UP. The first model (Model I) contained the direct effects of predisposing factors on compliance as well as the direct and indirect effects of the enabling factors. Model II added the regression of the enabling factors on reinforcing factors to examine the indirect effects of reinforcing factors. Model III added the direct effects of reinforcing factors on compliance, eliminating the indirect effects from Model II. In this manner, Models I to III were nested within the model specified in Figure 1. One additional model was also estimated. This final model (Model IV) contained only the direct effects of the three diagnostic factors; no indirect effects were included.

Aside from examining the absolute fit of the nested models (see Table 7), the change in chi-square per change in degree of freedom (χ^2/df) provided information regarding which additional paths resulted in the greatest improvement in model fit per degree of freedom (i.e., the greatest drop in chi-square per degree of freedom). The comparison of Model II with Model I provided a substantial reduction in chi-square per degree of freedom, demonstrating the extent to which reinforcing factors directly impact enabling factors, and through this route indirectly influence compliance. Overall model fit did not improve much when the direct effects of reinforcing factors on compliance were added (Model III), but this addition did produce the greatest improvement in R^2 for compliance with PPE. For general compliance, the indirect effects of reinforcing factors appeared to be more important in terms of predicting compliance. Finally, removing the indirect effects (Model IV) diminished both model fit and the R^2 values for both

Table 7
Goodness-of-Fit Statistics for the Structural Models

Model	*df*	χ^2	GFI	AGFI	NNFI	RMSEA	Compliance with PPE R^2	General compliance R^2	Model comparison	$\Delta\chi^2/\Delta df$
Full	1,154	2,429.95	.91	.89	.90	.035	.18	.41		
Nested										
I	1,189	3,143.86	.88	.87	.86	.043	.10	.33		
II	1,164	2,491.53	.90	.88	.90	.036	.10	.36	II vs. I	26.09
III	1,179	3,073.10	.89	.87	.86	.043	.16	.33	III vs. I	7.08
IV	1,209	3,403.07	.87	.85	.84	.045	.15	.31		

Note. GFI = goodness-of-fit index; AGFI = adjusted goodness-of-fit index; NNFI = nonnormed fit index; RMSEA = root mean square error of approximation. PPE = personal protective equipment.

compliance measures relative to the hypothesized model presented in Figure 1.

Discussion

This study sought to examine the contribution of the three diagnostic factors from the PRECEDE model to compliance with UP among nurses. The hypothesized model, which contained the direct effects of predisposing factors and the direct and indirect effects of both enabling and reinforcing factors, did a substantially better job predicting general compliance than compliance with PPE. This model explained 18% of the variance for compliance with PPE and a full 41% for general compliance. This difference is noteworthy in that the PPE measure contained several barrier-related UP behaviors that have shown characteristically poor rates of compliance in previous research (see Hersey & Martin, 1994; Nelsing et al., 1997; Roy & Robillard, 1994).

An examination of the regression coefficients in Table 8 reveals that the pattern of contribution of the three diagnostic factors differed considerably across the two compliance measures. None of the predisposing factors predicted compliance with PPE, whereas three of these factors predicted general compliance. Having more positive attitudes toward patients with HIV, lower risk-taking tendencies, and greater knowledge of modes of transmission in health care all predicted better general compliance.

Among enabling factors, the ready availability of PPE predicted better compliance with PPE but not better general compliance. On the other hand, perceiving fewer compliance-related job hindrances predicted better compliance on both measures. The importance of access to protective equipment for compliance with PPE should not be surprising, in that this measure included three problematic PPE-related behaviors: wearing protective outer garments, eye shields, and face masks. This result, however, does point to the importance of making it easy for HCWs to access these PPEs when and where they are needed. The importance of job hindrances for both compliance measures is consistent with previous studies of UP-related behavior (e.g., DeJoy et al., 1995; Kelen et al., 1990; Linn et al., 1990; Willy et al., 1990). Job-related barriers also have been shown to be important with respect to a variety of other workplace self-protective behaviors, including the use of hearing protectors (Lusk, Ronis, & Kerr, 1995), protective footwear (Cleveland, 1984), and respirators (Terrell, 1984).

The unique aspects of patient care as a work

Table 8
Regression Coefficients (Gamma): Compliance Regressed on Each of the Three Diagnostic Factors

Variable	Regression coefficient	
	Compliance with PPE	General compliance
Predisposing factors		
Effectiveness of preventive actions	.04	−.05
Attitudes toward HIV patients	.00	.11*
Risk-seeking tendencies	−.04	−.18**
General knowledge of HIV	−.01	−.10
Knowledge of alternative modes of transmission	−.03	.05
Knowledge of transmission in health care	.02	.16**
Enabling factors		
Availability of PPE	.15**	.06
Job hindrances	−.14**	−.35**
Workload	.00	.02
Training in UP	.05	.04
Training in PPE (in last 12 months)	.00	−.05
Reinforcing factors		
Priority assigned to safety	−.31**	.18
Formal feedback	−.27*	−.28
Informal feedback	.50**	.48*
Management actions/commitment	.16	.17
Prior exposures	−.01	−.10*

Note. PPE = personal protective equipment; UP = universal precautions.
* $p < .05$. ** $p < .01$.

activity suggest that job hindrances may be an especially important aspect of the compliance problem (DeJoy et al., 1996). The "product" in this work activity is human health and, in many instances, life itself. Furthermore, emergency and critical-care situations often involve split-second, lifesaving actions in which even minor performance delays or task encumbrances may have serious consequences. Two other dimensions also differentiate UP from most other instances of workplace self-protective behavior. First, compliance with UP has an interpersonal dimension. Instead of protecting the worker by providing a barrier between the worker and some environmental hazard, UP places physical barriers between two people. This almost invariably alters the interpersonal dynamics and complicates task performance and treatment to some extent. This situation is quite different from, say, the use of hearing protectors in a high noise environment. Second, HCWs often do not know the actual risk status of the patients they treat, and unlike many occupational hazards that are cumulative in impact, a single momentary lapse in compliance can lead to serious, even fatal, results. The reduction of job-related hindrances through the careful analysis and modification of patient-care tasks and the development of skills-based training may be important leverage points for improving compliance with UP. HCWs appear to have sufficient information about UP and occupational transmission of blood-borne pathogens. At this point, further improvements in compliance might be obtained by enhancing the actual skill levels of HCWs in practicing UP and in identifying and managing high-risk task situations. Presumably, such skills- or strategies-based training would boost the confidence or self-efficacy expectancies of the workers. This reasoning received at least partial support in the present study, in that specific training in PPE predicted greater confidence in the effectiveness of preventive action.

In addition to predicting compliance, job hindrances and availability of PPE, as aspects of the environmental system, also influenced predisposing factors in a positive manner. Experiencing fewer job hindrances predicted stronger beliefs in the effectiveness of preventive actions, more positive attitudes about patients with HIV, diminished risk-seeking tendencies, and greater knowledge about HIV, alternative modes of HIV transmissions, and HIV transmission in health care. Greater perceived availability of PPE predicted stronger beliefs in the effectiveness of preventive actions, more positive attitudes toward HIV patients, and greater levels of knowledge in each of the three areas measured.

Reinforcing factors were represented by the four safety climate dimensions and a measure of previous occupational exposure to potentially contaminated blood and other materials. Although reinforcing factors were not measured as well as the other two

Table 9

Regression Coefficients (Gamma): Predisposing Factors Regressed on Each of the Five Enabling Factors

	Predisposing factor					
Enabling factors	Effectiveness of preventive actions	Attitudes toward HIV patients	Risk-seeking tendencies	General knowledge of HIV	Knowledge of alternative modes of transmission	Knowledge of transmission in health care
Availability of PPE	.11*	.28**	−.08	.10**	.17**	.19**
Job hindrances	−.14**	−.29**	.12**	−.06**	−.17**	−.13**
Workload	.00	.01	−.05	.02	−.02	.13**
Training in UP	−.01	.00	.06	−.08**	−.13**	.01
Training in PPE	.13**	.07	.06	−.01	.04	.14**

Note. PPE = personal protective equipment; UP = universal precautions.
$^* p < .05$. $^{**} p < .01$.

diagnostic factors, the pattern of regression coefficient was quite interesting, especially for compliance with PPE. For this measure, better compliance was associated with more informal feedback but less formal feedback and less priority assigned to safety within the organization. This pattern of results suggests that improvements in compliance are more likely to come from informal point-of-use prompts than from official policy statements or from more formal types of safety performance feedback. There are several reasons why frequent informal reminders may be important in improving compliance with these particular barrier-type methods. First, these protective measures are less often indicated than those associated with needles/sharps manipulation and hand protection. As such, workers may be less accustomed to or less skilled in using these PPEs; they may also perceive them as being more uncomfortable or as interfering more with job performance. Second, protective eyewear, masks, and protective smocks may be less readily available than gloves or sharps disposal units. And third, the protection offered by these devices is less intimate or immediate as compared with actions that protect the hands or prevent sharps-related injuries. Informal feedback as an aspect of safety climate was also a relatively strong predictor of general compliance.

Also for reinforcing factors, greater prior occupational exposure to potentially contaminated materials predicted poorer general compliance. Needlesticks and other exposures should sensitize the HCW to the need for strict compliance; however, it is possible that they have the opposite effect. Such exposures may actually provide the worker with "evidence" that exposures cannot be completely avoided. These events might also represent examples of benign experience. Because infection or seroconversion rates are quite low, especially for HIV, most workers who are exposed to contaminated materials will not be infected. As such, prior exposures may not motivate compliance.

In terms of the effects of reinforcing factors on enabling factors (see Table 10), greater priority assigned to safety was associated with greater availability of PPE and fewer job hindrances. This is not surprising because assigning importance to safety should result in work environments that encourage and facilitate self-protective behavior. However, the coefficients for safety-related feedback were somewhat puzzling. Receiving more formal feedback predicted fewer job hindrances, but both types of safety-related feedback (i.e., formal and informal) predicted less availability of PPE. One possible

explanation is that for some health care units the basic approach to improving compliance may be simply to provide ample supplies of latex gloves, sharps containers, and other protective equipment and devices. More research is needed in this area to better understand the nature of safety climate and its relationship to workplace environment.

The nested models were used to explore the direct versus the indirect effects of reinforcing factors on compliance. This set of models revealed that the greatest improvement in fit occurred when the indirect effects of reinforcing factors were added. This suggests that a positive or supportive safety climate may increase the likelihood that the work environment will contain features or elements that enable workers to more readily comply with recommended work practices. If one looks at the R^2 values in Table 7, the largest single increase in R^2 for compliance with PPE occurred when the direct (vs. the indirect) effects of reinforcing factors were added. At least for these more problematic barrier methods, safety climate factors may act directly on compliance. Frequent and consistent feedback from coworkers and others may be especially important in prompting point-of-use compliance for these particular work practices. In contrast, the indirect effects of reinforcing factors appear to be more important for general compliance.

The overall results of the study suggest that enabling and reinforcing factors play important roles in the UP-related behavior. This finding is consistent with the logic of the PRECEDE model and with conventional wisdom in the safety field. Green and Kreuter (1991) conceptualized predisposing factors as providing the initial motivation for behavior but argued that appropriate skills, resources, and supportive environments were necessary to allow this motivation to be realized. It is almost axiomatic in the safety literature that adequate levels of knowledge and positive safety-related attitudes are necessary but seldom sufficient to produce and sustain self-protective behavior (e.g., DeJoy, 1996; Ford & Fisher, 1994; Lindell, 1994; Smith & Beringer, 1987; White & Berger, 1992).

Viewed together, the findings of this study suggest that the PRECEDE model provides a useful framework for examining the individual and environmental–organizational factors associated with compliance with UP among HCWs. A principal strength of this model when applied to workplace self-protective behavior is that the analysis of self-protective behavior extends beyond individual or person-focused variables. The PRECEDE model increases

Table 10
Regression Coefficients (Gamma): Enabling Factors Regressed on Each of the Five Reinforcing Factors

Reinforcing factor	Enabling factor				
	Availability of PPE	Job hindrances	Workload	Training in UP	Training in PPE (in last 12 months)
Priority assigned to safety	.45**	−.47**	−.30	.04	.05
Formal feedback	−.41**	−.72**	.52**	−.16	−.39**
Informal feedback	−.24*	.27	−.25	.25**	−.24
Management	−.04	−.01	−.12	−.05	−.51**
Prior exposures	−.05**	.12**	.11**	−.01	.03

Note. PPE = personal protective equipment; UP = universal precautions.
* $p < .05$. ** $p < .01$.

the saliency of environmental variables by directing attention to the skills and resources that permit the attainment of behavioral goals and by viewing the environment as an important source of support and reinforcement for sustaining self-protective action (DeJoy, 1996). The present results highlight the importance of readily available safety equipment and the need to identify and reduce job-related barriers to compliance. Although safety climate continues to be a rather poorly defined concept (Brown & Holmes, 1986; Dedobbeleer & Beland, 1991; Zohar, 1980), elements of safety climate do appear to influence the compliance process, either directly or by facilitating the creation of work environments that enable good compliance. Better elucidation of safety climate may further reveal its importance to workplace self-protective behavior.

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Received August 29, 1997
Revision received October 1, 1998
Accepted January 28, 1999 ■