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Active Learning: When Is More Better? The Case of Resident Physicians' Medical Errors

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An active learning climate facilitates new knowledge acquisition by encouraging employees to ask questions, seek feedback, reflect on potential results, explore, and experiment. These activities, however, also increase a learner's chances of erring. In high-reliability organizations, any error is unacceptable and may well be life threatening. The authors use the example of resident physicians to suggest that by adjusting the conditions of priority of safety and managerial safety practices, organizations can balance these potentially conflicting activities. Participants in the study were 123 residents from 25 medical wards. Results demonstrated that the positive linear relationship between priority of safety and safety performance, demonstrated in earlier studies, existed only when the active learning climate was low. When the active learning climate was high, results demonstrated a *U*-shaped curvilinear relationship between priority of safety and number of errors. In addition, high managerial safety practices mitigated the number of errors as a result of the active learning climate.

Keywords: active learning, safety climate, resident physicians, patient safety, errors

Active learning views learners as active participants in their own learning experience (Bell & Kozlowski, 2002; Frese, 1995; Kozlowski & Bell, 2006). Active learning is vital for professionals and specifically for professionals in high-reliability industries. Such industries are characterized by high uncertainty, highly complex tasks, and nonroutine activities. Thus, passive learning through step-by-step instruction on how to complete tasks cannot encompass all possible daily work situations, and learning necessitates flexibility and constant experimentation and exploration (Gittell, 2002; Keith & Frese, 2008). Professionals' learning cannot all be done purely "offline" (i.e., in classes and through simulation). There is no alternative to learning by doing, and for professionals most learning must occur "online" while they perform their tasks (Argote, 1999).

Errors are a natural by-product of active learning; as learners actively explore the environment, errors will inevitably occur (Keith & Frese, 2008). Errors are defined as unintended deviation from plans, goals, or adequate feedback processes as well as incorrect actions that result from lack of knowledge (Reason, 1997; Van Dyck, Frese, Baer, & Sonnentag, 2005). Employee errors can harm organizational performance (Reason, 1997). The possible damage of an error is even higher for professionals in high-reliability industries who execute high-risk functions with potentially life-and-death consequences; in this case, any error is unacceptable and may well be life threatening. As a result, high-reliability organizations try to eliminate errors by giving high priority to safety and by emphasizing managerial practices that ensure safety (Katz-Navon, Naveh, & Stern, 2005; Reason, 1997).

The present study examined resident physicians (residents) in the health care industry and their medical treatment errors. Residents are the frontline providers of the majority of inpatient medical care in teaching hospitals. Residency is a stressful and overwhelming period, during which residents work long hours and take responsibility for the lives of the patients in their care. Residents have tremendous responsibility, although at the same time they are novice practitioners who are in the process of learning and mastering their profession. For example, although novice residents practice using surgery simulations, they must also learn by performing surgeries under real-life conditions on humans.

Hence, there is a dilemma between, on the one hand, the residents' need to actively learn and explore, which is at the core of high-quality medicine and, on the other hand, the need to keep patients safe and eliminate medical treatment errors.

An Active Learning Climate and Employee Errors

True learning cannot take place without active experimentation (Lewin, 1951). Learners need the opportunity to practice and experiment so that learning retention and transfer can take place (Bell & Kozlowski, 2008; Debowski, Wood, & Bandura, 2001; Keith & Frese, 2008; Noe, 2008; Van Dyck et al., 2005). An active learning approach promotes inductive learning processes in which individuals are provided with unstructured opportunities to explore and experiment; discover; and infer effective strategies, rules, principles, and routine behaviors on the job (Condry, 1977; Frese et al., 1991). Active learning involves using trial-and-error processes, taking risks, and

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deviating from standard routines, as well as trying out new work processes, asking questions, seeking feedback, and reflecting on potential results (Edmondson, 1999; Hofmann & Stetzer, 1998; Lee, Edmondson, Thomke, & Worline, 2004; Levinthal & March, 1993; March, 1991; Sitkin, 1992). Active learning is guided by the situational emerging problems and is not predetermined or imposed. Decisions about what to explore and when to seek guidance are made by the individuals, and this gives them control of and responsibility for their own learning (Grief & Keller, 1990).

Active learning can be applied to departmental or organizational levels through use of the concept of climate (Kozlowski & Klein, 2000; Schneider, 1990). Climate is defined as "the shared perceptions of the employees concerning the practices, procedures, and the kind of behaviors that get rewarded, supported, and expected in a setting" (Schneider, 1990, p. 384). Given that multiple climates often exist simultaneously within a single organization, climate is best regarded as a specific construct having a referent; that is, a climate is a climate of something, such as a climate of service, of safety, or of learning (Schneider, White, & Paul, 1998). In addition, different units within the organization may have different levels of a specific climate as a result of the nature of their work, their unique interactions, their specific work conditions, and their specific managerial behaviors (Schneider, 1990). Hence, an active learning climate refers to the shared perceptions of the employees within a department or organization about the extent to which there is an emphasis within the department on asking questions, seeking feedback, reflecting on potential results, exploring, and experimenting.

An active learning climate may not invariably lead to higher performance and may in fact be insufficient or even dysfunctional under certain circumstances. A focus on active learning consumes time without assurance of results and may, therefore, reduce efficiency and detract from performance because of errors and unneeded repetitions of activities (Debowski et al., 2001; Edmondson, 1999). Additionally, active learning is associated with creativity and generation of novel ideas and innovative solutions that require divergent thinking and access to a variety of alternatives (Choo, Linderman, & Schroeder, 2007). Thus, it may generate more variation than can be effectively assimilated. Moreover, the high amount of feedback and information that employees seek as part of their active learning process may be "a double-edged sword," because feedback does not always increase performance and may even be detrimental to performance under certain conditions (Kluger & DeNisi, 1996).

In sum, an active learning climate may influence a unit's performance, and, in addition, cross-level effects of the unit climate can influence individual members' performance after controlling for the effects of individual-level factors (e.g., Zohar, 2000). Hence, we hypothesized the following (see Figure 1).

> *Hypothesis 1:* An active learning climate is positively related to the number of employee errors.

Moderators of the Relationship Between an Active Learning Climate and Employee Errors

Climate of Priority of Safety

A climate of priority of safety refers to the shared perceptions of employees regarding the balance maintained within their department between, on the one hand, work pace, workload, and pressures for productivity and, on the other hand, safety (Katz-Navon et al., 2005; Zohar, 2000). Safety in organizations, in general, is defined as freedom from accidental injury and is related to the safety of employees and other organizational stakeholders, such as the organization's customers (Perrow, 1984; Roberts, 1990). Working in a safe manner often entails working at a slower pace, investing extra effort, or operating under less than optimal conditions. Consequently, whenever work pressure increases, employees use a complex system of considerations to set the relative priorities for safety versus speed or productivity.

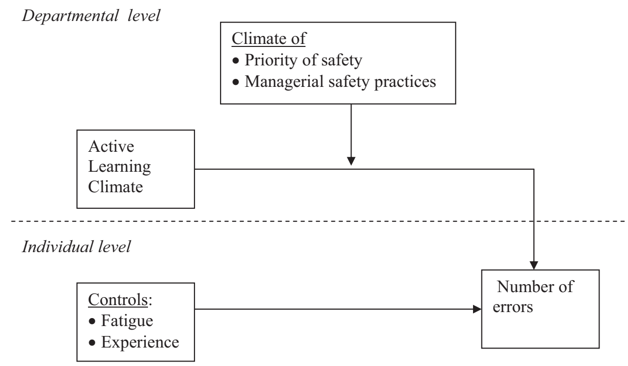

Figure 1. An integrated multilevel model of active learning climate, priority of safety, managerial safety practices, and individual number of treatment errors. The dashed line separates departmental-level constructs and individual-level constructs. The arrow crossing the dashed line represents cross-level relationships with the outcome variable.

A perceived high priority of safety means that safety is considered an important issue in the department that must be given precedence regardless of other competing demands, such as work speed and productivity. A high priority of safety can potentially motivate employees to take greater ownership of and responsibility for safety (Katz-Navon et al., 2005; Zohar, 2002).

Previous studies have suggested a linear relationship between employees' perceptions of the priority of safety and employee safety (e.g., Zohar, 2002). Traditionally, this relationship has been studied in high-reliability industries, such as steel factories (Brown, Willis, & Prussia, 2000; Zohar, 2002), offshore environments (Mearns, Whitaker, & Flin, 2003), and highly regulated environments such as the nuclear industry (Harvey et al., 2002). Katz-Navon et al. (2005) recently demonstrated the relationship between priority of safety climate and patient safety in the health care context.[1]

Climates of active learning and priority of safety coexist within organizations; for example, residents must learn as well as keep their patients safe. However, there are contradictory requirements

[1] In the health care industry, patients are the customers and patient safety refers to the avoidance, prevention, and amelioration of adverse outcomes or injuries stemming from health care processes. These adverse outcomes include errors and accidents caused by medical actions (in contrast to disease complications), events that result from equipment failure, failure to complete a planned action as intended (e.g., surgical events, events involving devices, patient protection, care), and use of the wrong plan to achieve an aim.

inherent in such a situation: The active learning process requires exploration, risk taking, and tolerance of mistakes, whereas a priority of safety emphasizes control and requires working by acceptable channels, planning, procedures, and rules. Adherence to a high priority of safety may thrive on commitment more than thoughtfulness, narrowness more than breadth (Gupta, Smith, & Shalley, 2006; March, 1996), whereas a commitment to learning thrives on thoughtfulness and breadth. Hence, safety may be compromised by emphasis on learning and vice versa. High emphasis on error prevention does not necessarily allow learning to occur (Sitkin, 1996), and some learning strategies, such as experimentation, are in direct conflict with the goal of priority of safety of error prevention.

Role theory suggests that individuals in organizations accomplish tasks by engaging in the roles that others within the organization expect of them (Katz & Kahn, 1978). For example, residents may perceive that there is a high expectation from them to learn, explore, and develop professionally. However, they may also recognize that they are expected, concurrently, to give patient safety a high priority. Katz and Kahn (1978) extended this argument to say that employees experience intrarole conflict when there is a "simultaneous occurrence of two or more role expectations such that compliance with one would make compliance with the other more difficult" (p. 204). Experienced role conflict, in turn, is negatively associated with employee performance. Thus, linking conflicting high climate of active learning with a high priority of safety will result in employees experiencing role conflict, and the result might be low safety performance.

In addition, maintaining a high active learning climate and a high priority of safety climate necessitates allocating resources from a limited organizational pool. Consequently, by definition, devoting more resources to active learning implies that there are fewer resources available for priority of safety and vice versa (March, 1991). Hence, the interplay between active learning and priority of safety occurs in the form of a zero-sum situation wherein both activities compete for scarce resources and attention.

Giving safety too low a priority denotes that safety-related activities are perceived as only rhetoric or as a pretense that can be inadequately followed or even ignored without consequences (Falbruch & Wilpert, 1999). The message may simply be too muted to direct employees' attention to maintaining safety. If, in addition, particularly strong emphasis is placed on active learning, there will be many errors.

We suggest that when the active learning climate is high, there is a curvilinear relationship between the perceived priority of safety and number of employee errors. Residents might perceive the priority given to safety as ranging between the two poles of "too much" and "too little" at an optimal intermediate level of priority. In this perceived optimal level of priority, safety performance would peak, because employees would be able to allocate the resources required to maintain safety and yet have sufficient resources for learning.

When the active learning climate is low, increasing the level of safety priority would improve safety performance, as resources would be allocated to safety and employees would experience less role conflict. Hence, we propose the following:

> *Hypothesis 2:* The climates of active learning and priority of safety interact in their influence on employee errors, such that there is a *U*-shaped relationship between priority of safety and number of errors when active learning climate is high and a decrease in the number of errors as the level of priority of safety increases and the active learning climate is low.

Perceived Managerial Safety Practices

Supervisors maintain safety by turning it into predictable, situation-specific action directives or practices. For example, managerial safety practices include identifying and eliminating the root causes of failures and hazardous conditions, identifying and correcting safety problems, and providing safety problem-solving information. These practices control employees' safety behaviors. Perceived managerial safety practices refer to employees' shared perceptions of the extent to which the supervisor executes safety-related activities and practices (Katz-Navon et al., 2005; Zohar, 2000, 2002) and expresses to employees the extent to which he or she is committed to safety.

Perceived managerial safety practices are consistent with the existing literature on transactional leadership that induces people to do things more reliably and efficiently by close monitoring and provision of contingent consequences (i.e., reward or punishment). Managerial safety practices influence safety performance by monitoring and rewarding or punishing behaviors that are needed to maintain reliable, efficient, and, hence, safe performance during job operations (e.g., Zohar, 2000, 2002).

Several studies have pointed to the positive impact on safety performance of supervisor practices that emphasize safety (Katz-Navon et al., 2005; Thompson, Hilton, & Witt, 1998; Zohar, 2000). The results of these studies showed that managerial safety practices that were perceived as promoting safety-oriented behavior led to high safety performance. Conversely, managerial practices that were perceived by employees as undermining organizational safety policies or that sent a message that safety could be ignored without consequences led to low safety performance.

When employees perceive that both learning climate and managerial safety practices are high, this may present them with a dilemma. On one hand, an emphasis on active learning increases the desire to learn and develop by experimenting and trying new and different things; on the other hand, managerial safety practices control employees' behavior by embracing work patterns that should be consistently applied and adhered to by employees.

Performance depends on the ability to balance learning and control. Organizations must standardize operations to ensure the reliability of outcomes and at the same time must keep themselves open and flexible to new ideas (Eisenhardt & Tabrizi, 1995; Sutcliffe, Sitkin, & Broning, 1999). Hence, although active learning and managerial safety practices may be perceived as contradictory, an argument can be made that employees should benefit from both. Optimally, the situation should be balanced to reap the potential benefits associated with both active learning and managerial safety practices. We propose that perceived managerial safety practices will moderate the relationship between active learning climate and the number of employee errors in the following way:

> *Hypothesis 3:* Managerial safety practices moderate the relationship between active learning climate and employee errors such that when managerial safety practices are high, active

learning climate is negatively related to the number of employee errors. When managerial safety practices are low, active learning climate is positively related to the number of employee errors.

Method

Sample

We distributed the study questionnaires to all the residents in two general teaching hospitals. Each hospital treats more than 100,000 patients annually. Participants were 123 residents in 25 departments (e.g., surgery, anesthesiology, cardiology, gastroenterology, orthopedics, obstetrics/gynecology, emergency medicine, pediatrics) in the two hospitals. This constitutes a response rate of 80%. Two thirds of the residents in one hospital were from 15 departments, and a third of the residents in the second hospital were from 10 departments. The number of respondents in each department ranged from 3 to 13. Of the respondents, 70% were men, 68.6% were in Years 1–3 of their residency period, and 31.4% were in Years 4–5 of their residency. Mean age was 32.5 years (SD = 3.93).

Measures

Group-level independent variables. On all scales, responses ranged on a five-point Likert scale from 1 (*to a very slight extent*) to 5 (*to a very large extent*). The active learning climate was assessed with five items drawn from Edmondson (1999; e.g., "To what extent do the following statements characterize your department's work environment?" "We are encouraged to try new things at work," "We frequently seek new ways to improve professionally"). Priority of safety was assessed with a six-item scale (Katz-Navon et al., 2005; e.g., "In your department, in order to get the work done, one must ignore some safety aspects," "Whenever pressure builds up, the preference is to do the job as fast as possible, even if that means compromising on safety"; both reverse scored). Managerial safety practices were measured with five items adapted from Katz-Navon et al. (2005). Residents were asked to rate their direct supervisor (e.g., "My supervisor monitors us more closely after a team member violates a safety rule," "My supervisor considers safety performance in performance evaluations and promotion reviews").

Individual-level control variables. We used the following control variables: (a) year of residency, which ranged from 1 to 5 years. This variable controlled for level of experience and knowledge. (b) Resident's level of fatigue, which was measured by the total number of night shifts the resident worked during the 3 months after responding to the questionnaire (Gaba & Howard, 2002).

Dependent variable. Treatment errors were defined as any error in the performance of an operation, procedure, or test; in the administration of treatment or in the dosage or method of using a drug; or as generally inappropriate care that resulted in an accident (i.e., harm to the patient; Kohn, Corrigan, & Donaldson, 1999; Leape, 2002). Kohn et al. (1999) provided a detailed list of potential treatment errors in each of these categories. On the basis of this list of errors, we asked four expert physicians (specialists in surgery, cardiology, pediatrics, and internal medicine) to limit the list to include errors that were potentially preventable, potentially severe, and potentially identifiable. The final list included 12 examples of potential errors across the medical specialization areas (e.g., prescribing the wrong medicine to a patient, mistakenly identifying a patient, using the wrong medical procedure).

Three months after the collection of the independent variables questionnaires from the residents, we administered the dependent variable questionnaires to the nurses. For each resident who answered the independent variables questionnaire, we asked a senior nurse to tally from the potential errors checklist the number of each type of treatment error made by the resident during the last 3 months (Brinkman et al., 2007; Landrigan et al., 2004). Each resident was evaluated by a different nurse who had been working closely with him or her and was familiar with the specific resident's work.

For 20 of the residents who participated in the study, we asked a second senior nurse who was familiar with the resident's work to tally from the same checklist the number of treatment errors made by the resident during the last 3 months. This was done in addition to the dependent variable evaluations in order to demonstrate the measure's reliability. We conducted a covariance analysis between the two evaluations of the same resident by the nurses using the SAS MIXED procedure (Raudenbush & Bryk, 2002) that fits a Poisson distribution. The results of the covariance analysis between the nurses' evaluations of the same resident were significant (covariance parameter estimate = 1.86, SD = 1.04, $p < .05$). In addition, we calculated the correlation between the two nurses' ratings (r = .83).

Results

Construct Validation

Independent variables. To test the structure of the three independent variables, we conducted a confirmatory factor analysis (CFA) using SAS's 9.13 CALIS procedure on the individual level of analysis. The analysis was performed on variance–covariance matrices with pairwise deletion of missing values. We employed a maximum-likelihood estimation method with robust standard errors together with the Satorra–Bentler rescaled chi-square statistic (Satorra & Bentler, 1994). The CFA yielded an acceptable fit level (Hu & Bentler, 1999), $\chi^2(111, N = 129) = 179.7$, p = .01, nonnormal fit index = .95, comparative fit index = .95, root-mean-square error of approximation = .069. All the standardized factor loadings in the model were above .60 (the majority of the loadings were between .70 and .80). Cronbach's alpha coefficients were as follows: active learning climate (α = .73), priority of safety (α = .88), managerial safety practices (α = .89).

Level of Analysis

The three independent variables of active learning climate, priority of safety, and managerial safety practices were considered group-level variables. That is, they reflected events occurring in the work unit that were shared or experienced by all individuals in the specific unit (Kozlowski & Klein, 2000). In order to justify the aggregation of the individual responses to the average department level, one must justify a within-department agreement (i.e., r_{wg} agreement index; James, Demaree, & Wolf, 1993). In addition, intraclass correlations (ICCs) indicated whether the measures were sufficiently reliable to model effects at the departmental level (Beliese, 2000). The active learning climate, priority of safety, and managerial safety practices scales exhibited sufficiently high average agreement (median r_{wg}= .93, .95, .94, respectively). The between-department effects based on the results of the one-way analyses of variance were significant at $p < .05$ for the three measures. This demonstrated that a significant proportion of the variance in individual responses could be accounted for by departmental membership (James, 1982). Intraclass correlations were adequate, ICC(1) = .16, .14, .17 and ICC(2) = .39, .37, .41, respectively. These statistics justified aggregation of the three independent variables to the departmental level (Beliese, 2000). Therefore, we calculated the mean score of each scale for each department by averaging the corresponding residents' ratings and assigning each resident his or her departmental mean score.

Hypothesis Testing

Table 1 summarizes the means, standard deviations, and correlations among the variables according to their different levels of analyses.

Because of the data's multilevel nested structure (a resident within a department within a hospital), we used a mixed-model data analysis method. Mixed models take into account the fact that individuals within one department may be more similar to one another than to individuals in other departments (Raudenbush & Bryk, 2002). In addition, the dependent variable—nurses' ratings of the number of treatment errors—had a Poisson distribution, because it was a count of infrequently occurring events that had only nonnegative integer values (Gardner, Mulvey, & Shaw, 1995). Thus, in order to test our hypotheses, we used the SAS GLIMMIX procedure (Littell, Milliken, Stroup, Wolfinger, & Schabenberger, 2006; SAS GLIMMIX Procedure Manual, 2006) that fits statistical models with nonindependence of observations where there is nonnormal distribution of the dependent variable. Finally, we centered the predictors, consistent with Aiken and West (1991).

Analysis begins with fitting an unconditional null model in order to estimate the total systematic variance in the (individual-level) dependent variable (Raudenbush & Bryk, 2002). This analysis clarifies how much variance resides within and between departments and hospitals and also serves as a foundation for later analyses. To effectively partial out these hospital and department variances and thereby eliminate the potential lack of residuals' independence, we dummy-coded for hospital (either first or second hospital) and department (from 1 to 25). Using GLIMMIX, we regressed the number of treatment errors on department within hospital. Results of this null model indicated that the proportion of the between-department variance to the total variance—that is, the ICC(1) value for the dependent variable—was .56, $\chi^2(104, N = 123) = 270.4$, $p < .01$. These results justify modeling departments within hospitals as cross-level effects.

To test the hypotheses, we entered the variables to the appropriate equations as follows: In Model 1, we entered the two individual-level control variables, year of residency and level of fatigue; in Model 2, we added active learning climate. In Model 3, we added priority of safety and managerial safety practices, as well as the two-way interactions of (a) priority of safety squared (to assess the possibility of a nonlinear relationship between priority of safety and number of treatment errors; Aiken & West, 1991); (b) active learning climate and priority of safety; and (c) active learning climate and managerial safety practices and the three-way interaction of priority of safety squared and active learning climate (see Table 2 and the Appendix for the GLIMMIX equations).

Results of Model 1 demonstrated that the two control variables by themselves significantly influenced the number of treatment errors. Results of Model 2 demonstrated a significant positive main effect for active learning on errors, which supports Hypothesis 1. Results of Model 3 demonstrated that the two-way interaction of active learning and managerial safety practices and the three-way interaction of priority of safety squared and active learning were significant. To understand the nature of these two significant interactions, we followed the graphing method outlined by Aiken and West (1991; high and low are ± 1 *SD*).

Figure 2 shows that the curvilinear effect of priority of safety on the number of treatment errors depended on the level of active learning climate. When active learning climate was high, there was a *U*-shaped relationship between priority of safety and the number of treatment errors. When active learning climate was low, the number of treatment errors decreased as priority of safety increased. This result confirms Hypothesis 2.

Figure 3 shows that when managerial safety practices were high, the number of treatment errors decreased as active learning climate increased. In addition, when managerial safety practices were low, the number of treatment errors increased as active learning climate increased. This result supports Hypothesis 3. When active learning climate was low, there were more errors when managerial safety practices were high rather than low. When active learning climate

Table 1
Means, Standard Deviations, and Correlations

Variable	*M*	*SD*	1	2	3	4	5	6
1. Year of residency	2.81	1.35	—					
2. Level of fatigue	18.37	5.0	.03	—				
3. Active learning climate	3.55	0.44	−.02	−.08	—			
4. Priority of safety	3.79	0.39	−.15†	−.04	−.11	—		
5. Managerial safety practices	3.40	0.44	.19*	−.14	.60*	−.04	—	
6. Treatment errors	1.34	3.44	.10	.07	.17*	−.06	.14†	—

Note. Correlations for year of residency, level of fatigue, and treatment errors are on the individual level. Correlations for active learning climate, priority of safety, and managerial safety practices are on the departmental level.
† $p < .10$. * $p < .05$.

Table 2
Results of Poisson Regression Analyses (N = 123)

Variable	No. medical treatment errors		
	Model 1	Model 2	Model 3
Intercept	−2.33 (3.60)	−2.40 (3.60)	−2.50 (3.70)
Year of residency	0.13* (0.06)	0.12* (0.06)	0.10 (0.06)
Level of fatigue	0.20** (0.08)	0.26** (0.08)	0.49** (0.10)
Active learning climate		0.72** (0.20)	−0.90 (0.53)
Priority of safety			1.32** (0.43)
Managerial safety practices			2.10** (0.48)
Priority of Safety × Priority of Safety			0.34 (0.58)
Active Learning Climate × Priority of Safety			−3.44** (0.71)
Active Learning Climate × Managerial Safety Practices			−2.15** (0.70)
Active Learning Climate × Priority of Safety × Priority of Safety			3.75** (1.13)

Note. Coefficient estimates are shown with standard errors in parentheses.
* $p < .05$. ** $p < .01$.

was high, the number of errors was similar when managerial safety practices were either high or low.

Discussion

Previous studies pointed out the advantages of an active learning climate for individual and team performances, such as improvements in effectiveness, innovativeness, and learning (e.g., Edmondson, 1999; Frese, 1995; Kozlowski & Bell, 2006). Yet, our results demonstrate that an active learning climate is also associated with relatively higher numbers of employee errors. Although some organizations can tolerate the cost of errors in order to gain the benefits of learning, others (e.g., high-reliability organizations) cannot.

An active learning climate is vital for professionals in general and novice professionals in particular, specifically for those in high-reliability industries (e.g., physicians in health care organizations, pilots and air traffic controllers in the aviation industry, engineers in nuclear power plants). On the other hand, minimal tolerance for errors is a highly important part of their performance. As a result, these two contradictory demands present professionals with a dilemma. This dilemma is acute in the context of the medical profession, which has traditionally vigorously emphasized professional learning by doing, as can be seen from the long-standing mantra of medical education "see one, do one, teach one." This philosophy promotes learning through experience. Yet simultaneously, physicians work under the Hippocratic dictum of "first do no harm."

Employee errors are not necessarily the complete fault of the individual employee but are also the result of organizational factors that can be controlled and changed. Although organizations tend to encourage active learning, priority of safety, and managerial safety practices all at the same time, this study showed that this is not necessarily the optimal combination for minimizing error rates.

Earlier studies on safety have tended to concentrate on the degree to which priority of safety exists and on the positive linear relationship between priority of safety and safety performance

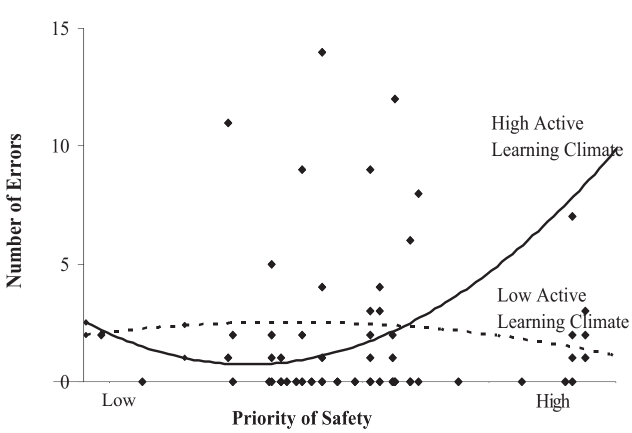

Figure 2. Scatter plot and regression lines of number of treatment errors as a function of priority of safety and active learning climate.

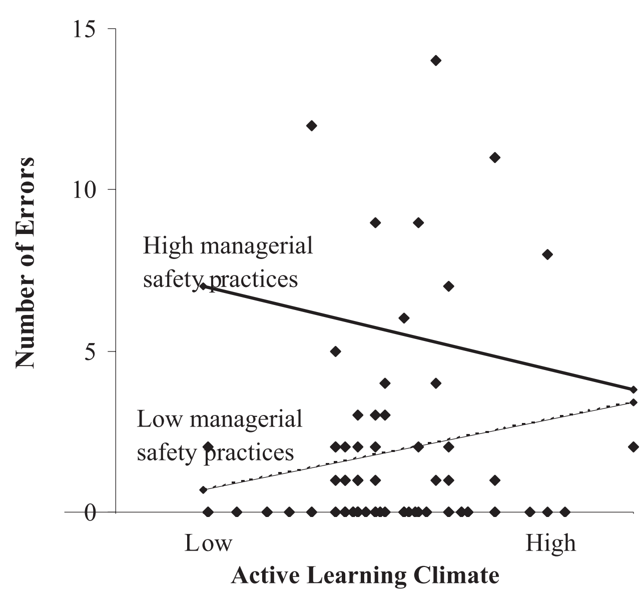

Figure 3. Scatter plot and regression lines of number of treatment errors as a function of managerial safety practices and active learning climate.

(Katz-Navon et al., 2005; Zohar, 2002). We demonstrated that this positive relationship existed when the active learning climate was low. However, when the active learning climate was high, there was a *U*-shaped curvilinear relationship between priority of safety and number of treatment errors. This demonstrated that too little but also too high an emphasis on safety may be detrimental to safety.

The results of the interaction between active learning climate and priority of safety suggested that a high active learning climate alongside an intermediate level of priority of safety was associated with a low number of treatment errors. A high active learning climate and a high priority of safety were associated with the highest number of treatment errors; employees who worked in an environment that strongly emphasized learning invested many resources in learning and improving but at the same time did not have the resources needed to keep priority of safety high.

Finally, when the active learning climate was low, there were fewer opportunities to err; hence, in general, the number of treatment errors, when safety was given a low or high priority, was small. Priority of safety is a more meaningful construct when there are many opportunities to err (i.e., when the learning climate is high).

The results of the interaction between active learning climate and managerial safety practices demonstrated that the higher the active learning climate, the fewer the treatment errors, when managerial safety practices were high. When the active learning climate was low, there were more errors when managerial safety practices were high than when they were low. Professional rules and ethics guide physicians' professional behaviors. Physicians, as a group, view their professional development and learning as superseding their organization's requirements (Scott & Backman, 1990). Thus, when the organization stresses, for instance, managerial safety practices more than professional doctrine dictates, the organizational intent is damaged.

Our results demonstrate that when active learning climate was high, high managerial safety practices resulted in few errors but high priority of safety resulted in relatively many errors. Previous studies (e.g., Hofmann, Morgeson, & Gerras, 2003; Zohar, 2002) grouped the factors of managerial safety practices and safety priority together when conceptualizing safety climate. Katz-Navon et al. (2005) demonstrated that priority of safety and managerial safety practices are two different factors that influence error rates differently. Our results in the present study provide additional theoretical and empirical evidence regarding the difference between these two safety climate factors and their different relationships with safety performance.

The literature on residents argues that the main factors that cause them to err are sleep deprivation due to extended work hours and circadian disruptions (Gaba & Howard, 2002; Lockley et al. 2004; Thomas, 2004; Weinstein, 2002). Although, as a result of these claims, residents' working hours have been shortened, residents' errors remain a major problem in teaching hospitals (see, e.g., Landrigan et al., 2004; Steinbrook, 2002). Our results show that level of fatigue did indeed have a positive association with error rates. Further reduction in the resident physicians' working hours might be impossible because of its high costs; hence, organizational factors that may influence error rates beyond level of fatigue are important.

Limitations and Future Research

The collection of data about errors in organizations in general and hospitals in particular can be subject to problems of willingness to report. In general, employees tend to underreport errors (Naveh, Katz-Navon, & Stern, 2006), and this study does not differ in this respect. One strong point here is the independent error count measurement; the reports given by independent nurses mitigate this problem to some extent. Nurses can detect many but by no means all medical errors; their great skill, experience, and professional training are supplementary to (if in some elements the same as) medical training.

As a retrospective measure, the dependent variable might be susceptible to forgetting and other cognitive distortions involved in recall. This problem may be less acute in the present study. The dependent variable's validity is acceptable because the informants were knowledgeable. Also, the measures concerned events rather than past opinions and beliefs, focused on facts and concrete events, and hence, were likely to be less subject to cognitive biases and impression management (Miller, Cardinal, & Glick, 1997).

The dependent variable counted errors that were known and immediately recognizable. However, some behaviors may be lagged in their consequences and, hence, may be conceived of as medically "unsafe" after the fact, when they are later perceived as having failed (Iszatt-White, 2007).

This cross-sectional research was conducted over a relatively short period. In future research, a longitudinal design would strengthen the ability to infer causality. Also, a longitudinal design would enable better understanding of other factors likely to be involved in the occurrence of treatment errors.

Becoming proficient at doing tasks safely may be an implicit part of learning to do these tasks. However, there is evidence that a focus on safety and task completion may change over the course of completing a task (e.g., Humphrey, Moon, Conlon, & Hofmann, 2004). Medical residency programs have the specific primary goal of creating competent clinical decision makers within a short period of time. Fulfilling the core mission of creating competent clinicians leaves little room for learning when concern is centered on patient safety and errors. Hence, these programs are also characterized by understated learning around errors (Frese, 1995; Hoff, Pohl, & Bartfield, 2006). Future research should compare the relationship between learning and errors over the professional career from novice to expert. Future research might examine whether the suggested relationship between learning and errors is general for all employees (including experts), holds only for professionals, or holds only for novices. Also, future research should explore other dependent variables, such as the learning outcomes of such interactions.

This study was concerned specifically with patient safety. Equating employee safety and patient safety suggests that a climate emphasizing safety would also be expected to reduce the number of work errors in general, regardless of the specific work context. Hence, future research should address the question of whether the results articulated in this paper hold for all types of work, all service work, or just medical work.

Practical Implications

Our findings might have benefits for high-reliability organizations, because they identify correlates of errors. Organizations implement active learning interventions in order to improve performance. However, the results of the present study demonstrate that organizations, and in particular high-reliability organizations, should balance the risk of increasing error rates in high-learning climates. In order to ensure safety, organizations should design interventions that target the three factors of active learning, priority of safety, and managerial safety practices. In doing so, organizations should acknowledge that both safety and learning require resources and that the intuitive tendency to maximize both of them does not necessarily result in best performance.

Organizations invest time and money in increasing the priority given to safety. The results of the present study demonstrated that this "linear approach" of organizations to increasing the priority of safety was not necessarily associated with good safety performance. Increasing the priority given to safety was not enough to reduce the number of errors when the active learning climate was high.

The study results imply the importance of the manager's role in reducing error rates. As such, the manager's share in safety management should be better acknowledged formally, so that it is clear that it is part of the manager's role. This matter should be further emphasized in professional organizations, in which managers tend to be professional role models. In sum, although active learning may increase the number of errors, organizations can still encourage learning and reduce errors by emphasizing the priority of safety to some extent and by using managerial safety practices to reinforce safety.

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Appendix

The GLIMMIX Equations for Calculating the Effects on the Number of Errors

$$\text{L1: } \log(\lambda_{ij(k)})_{ij(k)} = \beta_{0j(k)} + \beta_{1}(\text{year of residency})_{ij(k)} + \beta_{2}(\text{fatigue})_{ij(k)} + \beta_{3}(\text{active learning climate})_{j(k)}$$
$$+ \beta_{4}(\text{priority of safety})_{j(k)} + \beta_{5}(\text{managerial safety practices})_{j(k)} + \beta_{6}(\text{priority of safety})_{j(k)}$$
$$\times (\text{priority of safety})_{j(k)} + \beta_{7}(\text{priority of safety})_{j(k)} \times (\text{active learning climate})_{j(k)}$$
$$+ \beta_{8}(\text{priority of safety})_{j(k)} \times (\text{priority of safety})_{j(k)} \times (\text{active learning climate})_{j(k)}$$
$$+ \beta_{9}(\text{managerial safety practices})_{j(k)} \times (\text{active learning climate})_{j(k)}$$

$$\text{L2: } \beta_{0j(\mathrm{k})} = \gamma_{00} + u_{0j(k)}$$

where the terms are defined as follows:

Hospital	$k = 1, 2$
Department	$j = 1, \ldots, 25$ nested in hospital k
Resident	$i = 1, \ldots, 123$ nested in department j
(Medical treatment errors) $_{Ij(k)}$	$\sim$ Poisson ($\lambda_{ij(k)}$) medical treatment errors of the *i*th resident in the *j*th department in the *k*th hospital
$\beta_{0j(k)}$	The intercept; random effect
$\beta_1 - \beta_9$	Fixed parameters
(active learning climate)$_{j(k)}$ (priority of safety)$_{j(k)}$ (managerial safety practices)$_{j(k)}$	The independent variables' values for residents in the *j*th department in the *k*th hospital
γ_{00}	Mean intercept
$u_{0\,j(k)}$	Each department's deviation (department residuals)

Note. The GLIMMIX equations refer to Table 2, Model 3.

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