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Paradoxes of professionalism and error in complex systems

Matthew C. Holtman

National Board of Medical Examiners, Assessment Programs, 3750 Market, Philadelphia, PA 19104, USA

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ABSTRACT

Professionalism is at the heart of risk management in complex, dangerous work such as medicine, aviation, and military operations. Professionalism is closely connected to expertise and is therefore closely connected to the ability to prevent and mitigate errors. But there are two paradoxes in this connection. First, professionalism can increase, rather than reduce, the risk of errors and accidents by promoting practitioners' tendency to break procedural rules. This is because professional expertise tends to favor adaptation to local circumstances over standardized approaches to problem-solving. Second, professionalism can create blind spots within organizations, blocking the flow of critical information about unsafe conditions. This is because professional groups develop unique subcultures, specialized language, and communication habits that tend to separate them from other professional groups, even when those groups work within the same organization. I illustrate these paradoxes using case studies from several different professional domains. I then outline some methodological challenges for research on safety and professionalism. Finally, I argue that the kind of professionalism that can prevent errors is rooted in organizational practices that reduce the social separation between professional groups and promote the maintenance of adequate margins of safety. This requires the acceptance of safety as a central value that is at least as important as productivity.

1. Complexity, professionalism, and error

Complex systems have many interconnected parts whose interactions are difficult to anticipate. Complexity is fertile territory for error. Perrow explored the connection in his groundbreaking book *Normal Accidents*, in which he argued that some technologies are inherently dangerous because their complexity makes accidents inevitable [1]. Perrow's insights have been applied to complexity and risk in a variety of domains, including military aviation operations [2–4], nuclear defense systems [5], organizational planning for disaster [6], and medicine [7]. An important thrust of much of this work is its exploration of the interplay between organization-level and individual-level processes. In her fascinating case study of the Space Shuttle Challenger disaster, Vaughan uses the term "sociotechnical system" to describe a technology together with the organizations and environments in which it is embedded [8]. One of the most interesting features of research in the Normal Accident tradition is what it shows about the virtues and limitations of professional judgment in the face of technological and organizational failure.

Errors are unintended outcomes of purposive action. Professionalism and error are intimately connected in complex task settings. In a seminal essay on mistakes at work, the sociologist Everett C. Hughes argued that one of the defining competencies of professionals in any field is their ability to avoid, manage, and mitigate the social consequences of error [9]. Conversely, a number of researchers have identified lapses of professionalism as a contributing element of errors, error propagation, and adverse events.

Helmreich, for example, notes that flight crews who break minor safety rules are also at higher risk of making more consequential errors [10]. Professional culture, teamwork, leadership, accountability, and communication behavior have been linked to safety in complex, dangerous systems, including aviation and medicine [2,10,11]. Disruptive physicians can create a climate in which other health professionals are afraid to speak up about emerging safety concerns. Excessive fatigue impairs judgment and motor task performance, as does drug abuse, both of which have been framed as professionalism problems [12].

A paradox is a statement that seems contradictory but is nevertheless true. Deep relationships exist between professionalism and error in medicine and other high-risk fields, and in that relationship two paradoxes arise. First, professionalism and error are both deeply rooted in expertise. Second, professionalism creates social fragmentation that makes it harder for organizations to react appropriately to adverse events.

Expertise is the foundational element of professionalism. Without specialized skills and knowledge, a person cannot claim to be a professional, regardless of what other attributes or behaviors he or she exhibits. Expertise, in turn, implies adaptation: individuals

E-mail address: mholtman@nbme.org

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working in complex task settings tend to adapt to local conditions by adjusting the way they operate. In other words, professionals tend to change their routines in response to the particular challenges they face in any given environment. For example, in providing medical care to a low-literacy patient, a physician might decide to prescribe a drug that is considered medically less effective than the frontline therapy, but is easier for the patient to manage. This adaptation might reasonably be seen as a manifestation of astute clinical judgment or as an error, depending upon the patient's outcome.

Expertise is a defining element of both professionalism and error, and adaptation is the common mechanism underlying both phenomena. Adaptation to local conditions creates what Snook calls "practical drift," which he defines as "the slow steady uncoupling of local practice from written procedure" as participants realize that the written procedure no longer fits an operational environment that could not have been fully anticipated by planners [4]. Local resistance to "rule-based logics of action" [4] is often identified in retrospective studies as a precursor to accidents. But closer inspection usually reveals that practical drift, and more generally, routine noncompliance to established procedure [8], is found everywhere that professionals work [4,8,13]. Nonconformity to globally accepted routines and standards, in fact, arises from individual conformity to local professional norms [13]. Professionals are trained to break the rules when the rules do not fit the situation at hand. We expect it of them. The difficulty is in distinguishing between appropriate rule-breaking and rule-breaking that compromises safety.

The second paradox in the connection between professionalism and error is that professionalism can create organizational blind spots. Professionalism is associated with specialization and with the ways in which different specialist groups distinguish themselves from each other through professional subculture. The term "professional subculture" is a way of describing both a group of specialized professionals (such as tax lawyers, military air traffic controllers, or orthopedic surgeons) and the particular set of knowledge, skills, attitudes, beliefs, and language that separates them from other professionals and colors the way they look at the world. Professionalism is intimately tied to professional subcultures, and can therefore create social barriers to information flow within organizations, leading to "latent error" [14], or hidden defects in the way an organization operates, that can set the stage for system failure.

These paradoxes lead to some methodological observations regarding research on error and professionalism. Context-specific interpretations of professional behavior [15] are of central importance to understanding how incompatible professional norms are reconciled in the interest of balancing efficiency and control. How we judge a professional's behavior depends very much on what she is trying to accomplish at any given moment and what challenges she faces in trying to accomplish it. This has direct implications for the measurement of both professionalism and error.

Researchers must confront a tension between reproducibility and the rich description of events. Expertise for working in complex environments is highly "domain specific," which compels researchers to confront an essential tradeoff between reliability and validity, or stated differently, between reproducible but reductionist scores on the one hand and richly described, holistic accounts of performance on the other [16]. Case-based comparative methods are appropriate for understanding the causal nuances behind accidents and other adverse events and the reasons professional judgments succeed or fail, but large-scale statistical studies are important for establishing general principles and testing the impact of specific interventions. The right sampling approaches must be used, and those approaches differ depending on the goals of the analysis.

My focus is on professionalism and error in medicine. Sociologists have regarded medicine as the quintessential profession because of its unparalleled success in garnering prestige and control over the health care market during the past century. However, the argument I present is a general one, and I will borrow from case studies in aviation and the military to flesh it out.

Professionalism is an ideological construct, meaning that it has, in addition to its conceptual content, significant political overtones. Professionalism defines a high standard of conduct that its members must accept in exchange for the right to self-regulate and to control the market for the services they provide. Professionalism is therefore grounded in competition for resources and power differences between the professions (e.g. medicine, nursing, pharmacy) and between a profession and the organizations, such as hospitals, in which its work takes place [17]. Normal Accident theorists have noted that resource pressure is a primary driver of the adaptive processes that can undermine safety [1,18]. Accident prevention depends upon striking the right balance between safety and efficiency as competing professional virtues.

2. Two paradoxes

2.1. Professionalism and error are deeply rooted in expertise

A profession's right to self-regulate is founded in part on the premise of highly developed knowledge and skills that members of the public at large are not in a position to evaluate [19]. Specialized expertise is therefore the foundational element of professionalism.

Error implies a gap between intention and outcome. The very definition of an error is tied to time, place, and technology. Defining an event as an error requires that there be a right way to do things; there is no error without technique. As Light (1979, p. 310) puts it, "...any area of competence provides occasion for error." Technology changes constantly in medicine [20]. As the technical basis of practice evolves, new categories of error emerge. Adverse events that might once have been attributed to "exogenous" causes [21] such as deficient magic, witchcraft [19], patient history, or poor adherence to therapy can now be attributed to a failure of medical care, which constantly raises the bar for practitioners. When any patient who has received medical or surgical intervention gets worse or dies, the practitioner is socially compelled to face the possibility that the intervention itself contributed to the negative outcome [21].

Perrow (1984) has argued that some complex technologies are inherently dangerous. The elements of complexity that Perrow addresses include process invisibility; time-dependency and path invariance; nonlinearity; and the presence of dual-function components that can interact in unanticipated ways. These elements are intrinsic to the diagnostic and therapeutic technologies of medicine as well as to the underlying biological, physical, and chemical processes that govern human health and disease, creating fertile ground for uncertainty and error in the practice of medicine.

Traditional psychological categorizations of error are most relevant within closed systems in which the interactions between system components are stable and well understood [22]. These are also the conditions under which success depends less heavily on specialized skill and professional knowledge and more on adherence to established routine. In more complex systems where work conditions call for highly developed skills, errors are a resource that individuals and organizations use to adapt to local environmental conditions [18]. As a result, "routine noncompliance" becomes an essential and ubiquitous feature of complex organizations that cannot be disentangled from their basic work functions [8]. Snook argues that risk arises in the mismatch between logics of action

(rule-based versus task-based) and situational coupling (tight or loose) as a system moves, often subtly, through different phases of design and deployment [4]. Professional adaptation is a virtue within loosely coupled systems, but can quickly become a liability when the system's components begin to interact in unexpected ways.

The constant need to test complex systems empirically speaks to the importance of organizational learning for error management. Learning curves appear in many technological contexts, such as the design of new aircraft and aviation operations systems [23], the development of new medical and surgical techniques [24,25], and the "shakedown cruises" to which newly outfitted warships are subjected [3]. Submarines, at the beginning of a cruise, may be put through maneuvers known to American sailors as "angles and dangles" [26]: "...a series of random figure eights, sharp turns, and changes in depth meant to shake things out, to see what kind of noise a submarine is making, and to find out whether anything is stowed where it shouldn't be" before more taxing combat maneuvers are attempted.

The ability to identify and assess the gap between intentions and outcomes in a noisy environment is fundamental to learning at the individual level as well; witness the enormous literature on the psychology of feedback [27].

Complexity is inherent in medical care. Individual differences in anatomy, history, severity of illness, co-occurring disease, expectations, lifestyle, and tolerance of therapy cause patients to respond to care in unique ways. The ambiguities attached to the interpretation of imaging studies, test results, and physical examination sometimes make it impossible to know for sure what is happening with a patient. As a result, diagnosis and choice of therapy must often be regarded as hypotheses to be tested [18,28]; strategic use of error to find a beneficial course of treatment then becomes an indispensible element of practice.

Fadiman's celebrated account of a young Hmong girl's treatment for severe epilepsy by American doctors in California [29] provides an example of how expert adaptation to a complex environment is fraught with uncertainty. In an important narrative thread, physicians clashed with the girl's parents over her anticonvulsant medication. The girl had been prescribed Tegretal and Phenobarbital, but because of language and cultural barriers her family never fully understood the reason for the medication or how to administer it; they gradually discontinued the medication without telling the doctors, and the girl's seizures continued to worsen. Ultimately a decision was made to switch her to the anticonvulsant drug Depekane, which was considered medically less effective but was easier to take and more acceptable to the family since it did not make the girl "drunk." Some of the physicians involved struggled with this decision but later expressed regret that they had not tried the simpler regime sooner. This is a question of professionalism in which a technical issue is inextricably tangled up with an ethical one. Physicians have to balance their mandate to provide the highest quality of medical care with a realistic assessment of how their decisions will play out in an environment that they cannot fully control.

Physicians are acutely aware of the role that uncertainty plays in their work. The management of uncertainty forms a central component of medical training [21,30]. Even experienced doctors often struggle to distinguish between errors and unavoidable complications of treatment. To the extent that there is environmental variability, technological complexity, and ambiguity, practitioners are more uncertain about the possible iatrogenic contribution to a patient's condition [28], and are more reluctant to say that an error has been made when an adverse event occurs [9]. This reluctance often reflects the individual practitioner's recognition of his own limitations and the fear of judging another too harshly. Thus the very ability to recognize an error when it occurs is bound up in social processes of cognition. This leads to the second paradox.

2.2. Professionalism can create organizational blind spots

In addition to expertise, professionalism implies individual conformity to the profession's particular culture (and often to specialist subcultures within the profession), including norms of professional conduct and habits of thought that differentiate the profession's members from the rest of the public. A significant part of the social force behind professional specialization is to convey and reinforce one group's status and privilege relative to others. Professionalism can reinforce the social fragmentation and hierarchies of authority that exist within organizations, reducing effective information flow and increasing the potential for latent error.

Error can be either technical or normative in nature [21], and normative error often carries greater social consequences. Slips, lapses, poor technique and faulty decision making fall under the category of technical error, while violation of the behavioral expectations of colleagues is normative error. In a unique field study of surgical residency training, Bosk finds that normative error among surgical trainees tends to be treated more seriously, by both housestaff and attending physicians, than technical error. A failure to keep one's attending physician fully informed about a patient's condition, for example, or an inability to work well with the nursing staff, may be taken as signs that a trainee lacks the requisite honesty and responsibility to be a good surgeon.

But the category of error that elicits the most severe social sanction is what Bosk calls "quasi-normative" errors, which are violations by residents of the idiosyncratic technical preferences of their supervising attending surgeons, even when no technical error has occurred. Quasi-normative errors are violations of "the way we do things around here." They signal insubordination to authority rather than incompetence. The significance of this category of error lies in how it is used to manage the moral development of residents; quasi-norms are used to teach residents how to deal with areas of practice in which existing knowledge is inadequate to provide clear guidance. The quasi-normative error phenomenon suggests that the social forces driving conformity to local work culture are at least as strong as the forces driving technical conformity [13].

The norms of medical professionalism are often in conflict, as they are in all integrated normative systems [31]. In addition to the "avowed" norms of altruism, empathy, etc., medical students also inevitably absorb "disavowed" norms that include collegiality, loyalty to the profession and the work group, and deference to authority [32], all of which serve the solidarity of the profession and the team and help the profession maintain its collective control over the public, but tend to undermine clear communication about risk and adverse events.

The usual ways in which errors are managed within a profession tend to be exercises in ritual imbued with social biases. Errors are "essentially contested" events [21] that arise at the limits of our cognitive capacity and at the margins of social control. This makes them slippery and prone to social manipulation. Bosk shows, for example, that one effect of traditional surgical morbidity and mortality review conferences is to reinforce the existing social structure of residency training by highlighting the authority relations that govern the hospital [21].

Professionalism demands conformity to the rituals, normative expectations and habits of the organization's professional subculture(s) [8]. Light argues that trainee physicians manage uncertainty not only by mastering knowledge, but by limiting the knowledge that they *have* to master—and closing off potential avenues of inquiry and action—by adopting a school of thought. All professions also face the need to manage uncertain relations with the client, the public, and other professionals. Both aims are furthered through specialization [33].

Professionalism requires the socialization of individuals into specialist subcultures that think, act, and communicate differently from one another, creating powerful barriers to information exchange across subcultures. Two examples from the military will illustrate. Snook provides a masterful case study of the accidental shootdown of two friendly helicopters by US fighter jets during the first Gulf war [4]. A critical contributing factor was the social separation between the helicopter pilots and the fighter pilots, who operated in different environments, communicated with mutually incompatible radio systems, and held radically different cognitive models regarding the use of airspace. The fighter pilots flew high and fast, prided themselves on precisely following a predetermined schedule, and habitually coordinated their actions with other coalition aircraft sharing the same airspace. In contrast, the helicopter pilots were accustomed to flying low, irregular flight paths over the rugged desert terrain, navigating by visual landmark, and changing plans spontaneously, often without communicating their intentions to anyone else. There was strong pressure on both groups to limit their radio communications to short, essential utterances. These survival adaptations worked well within each separate operational domain, but they set the stage for disaster when the fighters and helicopters unexpectedly crossed paths. The fighter pilots' extensive air combat training predisposed them to make split-second judgments but did not provide any procedure for dealing with helicopters, which normally posed no threat to them. Incompatible transponder systems and differences in altitude and airspeed prevented the fighter pilots from accurately identifying the helicopters. In the space of about 8 min, the fighter pilots made initial contact with the helicopters, concluded they were hostile, and destroyed them.

Both innovation and error are forms of deviance [9,34]; the difference between them often lies only in whether the desired outcome has been achieved. Bowden describes another military misadventure involving a group of US soldiers who were nearly overrun by hostile forces while conducting a raid on suspected warlords in Somalia [35]. Contributing to the fiasco was significant social friction between the elite Ranger and Delta Force units participating in the joint operation. That friction stemmed from differences in experience, training, and professional subcultures. The Ranger commander demanded deference to his authority and adherence to established procedure and battle plans. The Deltas, in contrast, resisted traditional military hierarchy in favor of a flat teamwork model, carried custom-made weapons, sported civilian-style haircuts and facial hair, and operated on a much more improvisational basis. The Deltas were held in great esteem by the young, inexperienced Rangers, who imitated them and eagerly learned their tricks of the trade. The Deltas' specialized skills and flexibility allowed them to operate efficiently in extremely challenging combat situations but were not compatible with the integration of a large, diverse team. The Deltas preferred to carry only the weapons and equipment they thought they needed for a specific mission in order to minimize weight and increase their mobility; to the initial discomfort and later chagrin of the Ranger commander, the group chose to leave behind their night vision equipment. This became a serious liability when the group was pinned down by enemy forces after dark. As things started to go wrong, the team quickly became fragmented. The Delta operators kept moving, believing that staying still would get them cornered and killed; the Rangers tried to stay in place to establish a better defensive position. Voice and radio communications were hampered by battlefield noise and by a poorly integrated radio command network. The Deltas communicated with each other through hand signals but often could not get the attention of the Rangers, who accidentally fired on the Deltas on several occasions. The team was eventually rescued by an armored convoy but incurred heavy casualties.

Because it tends to create and reinforce social fragmentation, specialization tends to undermine the transparency, standardization, and team cross-training needed to promote resiliency to complexity and danger [11]. Specialization and professional socialization tend to create professional cliques through the well-established principle of social homophily [36]: professionals who share a common training background tend to work, communicate, and socialize with each other rather than with professionals from other groups, resulting in locally dense but globally fragmented social networks. This fragmentation can contribute to what Vaughan calls structural secrecy [13], or "the way that patterns of information, organizational structure, process, and transactions, and the structure of regulatory relations systematically undermine the attempt to know and interpret situations" within organizations.

Further reduction in the efficacy of communication occurs through the chilling effect that collegiality tends to have on error disclosure and on the informal social control of professional conduct and competence. Physicians are frequently unwilling or unable to sanction each other for incompetence or misconduct, undermining the promise of effective professional self-regulation [37–39]. The impulse not to discuss and fully examine adverse outcomes, in turn, deprives the individual and the group of critical lessons learned.

3. Research challenges

The connection between professionalism, error, and expertise implies that all three are inextricably bound up with local circumstances. Research approaches to professionalism and error must therefore address local context in a meaningful way [15,40]. This involves a certain amount of compromise between the reproducibility of analysis and the richness of the resulting interpretations.

Rasmussen notes that when a sufficiently detailed history of an accident has been constructed to render it recognizable to practitioners, it tends to lose its usefulness as a general case; its uniqueness threatens to overtake its value as a lesson learned [22].

An example comes from the conflict that arose between American and Egyptian aviation authorities during their joint investigation of the 1999 crash of EgyptAir Flight 990 in the Atlantic Ocean near Nantucket [41]. Based on a reconstruction of what happened on the flight deck using information from the flight data and cockpit voice recorders, the American National Transportation Safety Board (NTSB) quickly concluded that no mechanical failure had occurred and that an Egyptian co-pilot had deliberately flown the plane into the sea. But the Egyptian authorities found this conclusion intolerable and insisted on a lengthy and expensive investigation that included wind-tunnel research, computer simulations, and ground tests to evaluate the possibility of a hydraulic system failure that could have caused the Boeing 767 to pitch violently downward. Perhaps the American authorities reached premature closure due to arrogance and cultural insensitivity. But the extended investigation merely reinforced the NTSB's belief in the "simplest explanation," that the crash was deliberate and not the result of mechanical failure. Perhaps the Egyptian authorities wasted considerable time and money constructing a fantasy scenario to save face and avoid confronting the cultural taboo of suicide. In either case, the uniqueness of the disaster makes it difficult to derive any specific safety lessons from it. Instead, it illustrates the difficulty of recognizing one's own biases, as they arise from cultural lenses that shape everything we see.

The two major approaches to error analysis that have been widely embraced in medicine following the Institute of Medicine's landmark 1999 report [7] are critical incident reporting [42–44] and root cause analysis [45]. These methods share the characteristic of being largely qualitative in orientation, which lends them

richness and credibility to practitioners. They are also based on relatively small samples (because accidents are still relatively rare) and retrospective—they can only be activated once an adverse event has occurred. These features put strong limits on their reproducibility and raise the problem of hindsight bias as well as more subtle social distortions. In complex, unbounded systems, Rasmussen argues, there is no satisfactory "stop rule" that can effectively limit the investigation to the conditions that are most relevant to the outcome being investigated, so the social goals of the analysis tend to dictate its scope [22]. Retrospective accident analyses are therefore prone to becoming ritualized expressions of the existing social order.

Case-oriented methods are still appropriate for the study of accidents; the major challenge arises in how one approaches sampling and data collection. Ragin shows that sampling methods for traditional variable-oriented statistical research, which tends to be designed to address patterns of probabilistic co-variation among variables, is not appropriate for research in which the goal is to establish the necessary and/or sufficient conditions contributing to a phenomenon in a deterministic relationship [46]. To address those questions, it is appropriate to sample on the outcome and on the causal condition under investigation, respectively. This will be counterintuitive to many researchers trained in multivariable statistical research methods. The case-oriented approach is liberating because it frees us from having to consider the many cases in which neither the outcome (an accident) nor a suspected contributing cause (say, noncompliance with safety rules) is present, because such cases are irrelevant to the analysis. This is a method ideally suited to rare events that occur through the alignment of several unusual circumstances, which is precisely the domain of events that normal accident theory addresses in describing general principles about complexity in sociotechnical systems. Although the details associated with any specific case are unlikely to be broadly replicable, general principles can still be derived and then investigated with larger-scale statistical research.

Risk-adjusted health outcomes research [47] provides a useful model for translating the insights derived from case-oriented research to a framework in which population-level and organization-level interventions can be investigated. Health outcomes research typically uses large available observational datasets to investigate the clinical significance of medical interventions while controlling for multiple confounding factors. While not as powerful as randomized experiments for making causal inferences, outcomes research provides a compelling tool for generalization. Its primary weaknesses are associated with its dependence on data streams that can be extremely unreliable [48], and with the difficulties of defining intermediate-level adverse outcomes (short of death) that happen frequently enough to be useful in statistical analyses but are unambiguous as danger signals. Further challenges lie in developing sufficiently sophisticated risk adjustment models, but these are of secondary importance relative to the data quality issues.

The assessment of professionalism introduces further challenges. Professionalism is at best an ambiguous, contested construct that does not lend itself to highly reliable measurement. Current approaches to the assessment of professionalism fall into two major categories: psychological assessments designed to measure trait-oriented constructs such as empathy [49] or moral reasoning [50], and observation-based methods such as critical incident [51,52] and patient complaint [53] reporting, live structured assessments based on simulated [54] or real patient encounters [55], and peer ratings or multisource feedback [56–61]. In general, attitudinal and trait-oriented assessments are problematic because of their poor predictive power with respect to behavior [15,62], but they may be important elements of a multi-method assessment toolkit. Because of the inherent difficulties of measurement and the probabilistic relationships between variables, generalizability theory is the most appropriate framework for sample design. Generalizability theory provides a systematic approach to sampling design to ensure the reliability of measures and to support valid inferences about the performance domain of interest, taking into account various sources of statistical error [63]. So far very little evidence on the reliability, content validity, or practicality of methods to measure professionalism has been published [64]. The context-dependency of professional behavior implies that adequate generalizability will need to address individuals' variability in performance as they encounter a variety of situations and problems [54,65]. Getting a handle on this will require attention to the multiple contexts of social interaction in which professional behaviors are manifested and will ultimately involve the adaptation of generalizability theory to support what amount to different varieties of systematic social observation [66]. The vocabulary available for describing the contexts of professionalism in medicine is still limited, though the language of "clinical microsystems" [67–69] begins to capture it. Substantially more research is needed to define and describe how the enactment of professionalism varies across the multiple microstructural contexts in which physicians operate. The actual (rather than the presumed) social microstructure of clinical training programs has not been deeply examined; assessment may need to be much more tightly interwoven with curriculum design [65] to ensure that trainees are being mentored, monitored and supervised appropriately and can thus be assessed on a continuous basis using data streams derived from the rich matrix of clinical experience [40].

4. Conclusions

Professionalism is an ideological construct that can be wielded in the interests of the profession rather than the interests of the public. Resolving the paradoxes of professionalism and error requires us to recognize that professionalism comes in many flavors. Professionalism arises through the interplay of individual behavior and organizational structure. Thus, the norms of professionalism are embedded within aggregate social forms. The kind of professionalism that is most conducive to safety is rooted in organizational practices that place as much emphasis on maintaining operational slack as on maximizing short-run cost efficiency. The most insidious problems facing safety in medicine and many other dangerous industries are rapidly changing technology and economic pressure [11,22]. Economic pressure undermines safety not so much through calculated decision making by amoral administrators [13], but by pushing systems relentlessly toward higher productivity while eroding the margins of control. This happens because the "defenses in depth" that are designed into most complex systems tend to buffer the impact of any individual act of deviance, so that the system itself reinforces individuals' tendency to cut corners, facilitating practical drift over the long run [18].

So-called "high reliability organizations" use considerable redundancy, especially of personnel, to manage risk in the complex, dangerous technologies they operate [1–3]. This redundancy requires constant cross-training of personnel and a large available pool of generalists who can step in and take over any number of functions when the system becomes overtaxed. These elements are not commonly found in contemporary US medical systems, where staff and resources are increasingly stretched to their limits in an effort to increase productivity. Production pressure, in turn, may be driven by large capital expenditures on diagnostic and therapeutic technologies that are needed to maintain market competitiveness. In this environment, professionalism quite naturally evolves to emphasize efficiency and adaptation. Staff learn to implement informal "work-arounds" that undermine safety pro-

cesses in order to cope with poorly functioning systems. It becomes a professional virtue to hoard supplies, bypass safety procedures, disable alarms, and find creative ways to defeat information systems designed to prevent medication errors [70–73]. At the same time, traditionalist training models, antiquated record-keeping practices, and poorly integrated legacy computer systems reinforce the social separation of physicians, nurses, pharmacists and other health professionals, making standardization and interprofessional communication very difficult.

Freidson argues that professionalism provides a "third logic" that can counter the extremes of unregulated markets on the one hand and heavy-handed regulatory bureaucracy on the other [74]. His vision depends on professional knowledge having an "attachment to a transcendent value that gives it meaning and justifies its independence" (p. 220). Professionalism inevitably requires the balancing of conflicting norms, and the health community's struggle to find that balance may serve as an example to other professions. Safety is a transcendent value that should be placed at least on a par with productivity. Further research is needed to establish which models of healthcare organization and financing, training, assessment, and regulation are most effective at nudging the professional cultures of medicine in directions that favor interprofessional communication [69], humility, accountability, transparency, standardization, and shared understanding [11].

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