

# The Predictive Value of Risk Categorization in Schizophrenia

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**Background:** Risk assessment is increasingly used to inform decisions regarding the psychiatric treatment of patients with schizophrenia and other serious mental disorders. **Aims:** To examine the theoretical limits of risk assessment and risk categorization as applied to a range of harms known to be associated with schizophrenia. **Methods:** Using known rates of suicide, homicide, self-harm, and violence in schizophrenia, a hypothetical tool with an unrealistically high level of accuracy was used to calculate the proportion of true- and false-positive risk categorizations. **Results:** Risk categorization incorrectly classified a large proportion of patients as being at high risk of violence toward themselves and others. **Conclusion:** Risk assessment and categorization have severe limitations. A large proportion of patients classified as being at high risk will not, in fact, cause or suffer any harm. Unintended consequences of inaccurate risk categorization include unwarranted detention for some patients, failure to treat others, misallocation of scarce health resources, and the stigma arising from patients' being labeled as dangerous. (HARV REV PSYCHIATRY 2011;19:25–33.)

**Keywords:** homicide, risk assessment, schizophrenia, self-harm, suicide, violence

## INTRODUCTION

Risk assessment is increasingly incorporated into the routine clinical care of people with schizophrenia and other

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mental disorders.<sup>1–10</sup> In a recent review of risk assessment, Buchanan<sup>4</sup> concluded that psychiatrists and psychologists now have “a range of methods [that] consistently predict violence at levels of accuracy better than chance.” The “methods” referred to are methods of “risk assessment,” which include clinical judgment, the use of instruments derived from studies of factors associated with harmful behavior, and a combination of these methods—sometimes referred to as “structured clinical judgment.”

Risk assessment in mental health is not without its critics. For example, Szmukler<sup>11</sup>—using the sensitivity and specificity from three studies of risk assessment—demonstrated how the base rate of future violence affected the likely proportion of correct predictions, and highlighted some ethical dimensions of risk assessment, including how an acceptable false-positive rate should be determined. More recently, Mossman has used an analysis of the *Tarasoff* decision as a starting point for critical analysis of the assumptions and mathematics implicit in risk assessment. He concluded that the adoption of risk assessment would not improve community safety<sup>12</sup> and would entail the cost that clinicians would come to view patients as “statistical sources of risk” rather than as “sources of initiative and moral worth.”<sup>13</sup> Some authors have taken a middle ground, acknowledging the limitations of risk assessment but cautiously advocating its use, at least in some circumstances.<sup>4,6</sup>

Much of the debate about risk assessment has not been about its use *per se* but has instead focused on the utility of risk-assessment instruments (sometimes referred to as actuarial methods), versus clinical judgment, to predict future harm.<sup>4,13</sup> However, there is a conspicuous absence of studies to show that any form of risk assessment can actually reduce harms such as assault, suicide attempts, suicide, or homicide. In the only study to show a reduction in harm after systematic risk assessment (of violence on an acute ward), the decline was probably due to a factor other than the prediction of harm, as only one in ten predictions of violence were correct.<sup>8</sup>

In this article we examine the problem of misclassifying patients into either high- or low-risk categories, acknowledging earlier articles examining this question, such as those by Szumukler<sup>11</sup> and Mossman.<sup>13</sup> We use empirically derived figures for the rates of harmful events associated with schizophrenia to estimate the predictive value of an optimal form of risk assessment and categorization of patients with this disorder.

We use the term *risk assessment* to describe any process of systematically identifying the factors associated with future adverse events. Hence, documenting patterns of nonadherence to medication or of substance abuse would be considered to be forms of risk assessment, as would the administration of structured instruments, such as the Psychopathy Checklist–Revised,<sup>14</sup> Historical Clinical Risk Management–20,<sup>15</sup> Manchester Self-Harm Rule,<sup>16</sup> and the SAD PERSONS scale,<sup>17</sup> which provide scores for categorizing patients into groups with an increased probability of harm.

We use the term *risk categorization* to refer to the use of risk assessment to categorize individuals into high- or low-risk groups on the basis of the estimated probability of their harming themselves or someone else. Although risk categorization relies upon risk assessment, it is a distinct and separate stage in risk management. For example, the same risk assessment can be used to make different risk categorizations if higher or lower cutoff scores are chosen. Categorizations based on instruments derived from studies of specific populations have been shown repeatedly to calculate the probability of harm more accurately than unstructured clinical methods.<sup>18</sup> For the purposes of this article, however, no distinction is made between risk categorization using predictive instruments and that using clinical judgment alone.

We use the term *individual risk management* to describe any treatments or other interventions, over and above treatment as usual, taken to lower risk on the basis of a risk categorization of an individual patient. *Individual* risk management is distinct from *organizational* risk management, which aims to reduce the probability of harm to *all* patients. Placing a patient with schizophrenia into a high-risk group

could result in coercive or involuntary care, additional supervision, reduced privileges, or higher doses of medication, among other interventions.

This article focuses on our ability to predict harmful behavior and on the unintended consequences of risk categorization. We use the example of patients with schizophrenia because the harms associated with this illness have been extensively studied. We first examined published research in order to estimate the rates of adverse events before and after the initial treatment of schizophrenia. Next, we examined published accounts of the sensitivity and specificity of predictions arising from risk assessment and categorization. We then used the example of a hypothetical risk-assessment instrument (with predictive values greater than that of any existing instrument) to estimate the ratio of true-positive predictions of harm to the total of all high-risk categorizations of people with schizophrenia. Finally, we considered the likely consequences of risk categorization for patients with schizophrenia.

## METHODS

**The Epidemiology of Adverse Events in Schizophrenia.** The base rates of adverse events in schizophrenia were taken from searches of subject headings, keywords, abstracts, and titles in PubMed/Medline from 1970 to 2009, using the following search terms: schizophrenia OR psychosis OR mental illness AND suicide OR self harm OR homicide OR violence. Base rates for the following harmful events were sought:

- suicide in people with treated schizophrenia
- attempted suicide in people with never-treated schizophrenia
- assault by people with treated schizophrenia
- assault by people with never-treated schizophrenia
- convictions for violent offenses in people with treated schizophrenia
- homicide by people with treated schizophrenia
- homicide by people with never-treated schizophrenia
- homicide of strangers by people with schizophrenia

We examined the proportion of patients experiencing or causing harm over a one-year period, or in the case of never-treated people, the rate of harms reported in studies of first-episode psychosis. We found no studies that reported rates of suicide or violent crime other than homicide in people with never-treated schizophrenia. In the studies of cohorts of known patients in which the rate of a harmful event was not reported directly, an annual rate of the adverse event was calculated by dividing the number of events by the total number of patient years. Although harms might be predicted with a greater sensitivity and specificity in the short term, few studies report the results of short-term predictions of harm, and most prospective and retrospective

studies report the number of events over a period of several years. Furthermore, rates of harm in a short period of observation are inevitably lower than rates of harm in a longer period, thus reducing the positive predictive value of short-term risk categorization. Longer periods of risk, such as a lifetime risk, were not considered because it is unlikely that individual risk-management strategies, such as involuntary treatment, would be designed to last for more than a year on the basis of an estimation of risk. The proportion of adverse events in never-treated patients with schizophrenia (and related psychosis) was used as the rate for each of the adverse events prior to treatment, because the duration of untreated psychosis in advanced countries is about one year.<sup>19</sup> Whenever possible, pooled estimates of the rates of adverse events were taken from systematic reviews. An estimate of the rate of adverse events was made using the middle value reported in the published studies when a pooled estimate was not available from an earlier study.

**Sensitivity and Specificity of Risk Categorization.** Few studies report the sensitivity or specificity of methods of predicting adverse events solely in groups of patients with the diagnosis of schizophrenia. Hence we also considered studies reporting the sensitivity and specificity of the prediction of adverse events in the broader class of “patients with mental disorders.”

In order to locate studies reporting the sensitivity and specificity of methods that might be used to categorize patients on the basis of adverse events, we searched the subject headings, keywords, abstracts, and titles in PubMed/Medline from 1970 to 2009 using the following search terms: risk assessment OR sensitivity AND violence OR homicide OR suicide OR self-harm. We excluded studies of prisoners with psychiatric disorders.

We included results derived from factors identified solely for the purpose of designing harm-prediction instruments, from studies designed to validate established risk-assessment in-

struments, and from systematic examinations of the associations between clinical and demographic factors and harmful events. Risk-prediction models developed by examining factors in an initial sample of patients do not perform as well when applied to subsequent samples.<sup>20</sup> However, since very few experimentally verified tools are available, we did not distinguish between the sensitivity and specificity of published results from the original samples, on the one hand, and the results derived from the subsequent applications of risk-assessment instruments to other groups of patients, on the other. Most of the studies included some discussion of the trade-off between sensitivity and specificity in the use of risk-assessment scores. In those studies that reported more than one figure for sensitivity and specificity, we used the sensitivity and specificity that maximized the number of correct categorizations. In some instances, the sensitivity and specificity were not reported directly but could be calculated using the data provided. Definitions of “sensitivity,” and “specificity,” and “positive predictive value” appear in the text box.

After examining the published literature, a hypothetical instrument for risk categorization (HIRC) was then invented along the lines suggested by Mossman,<sup>12,13</sup> who used a hypothetical “future violence test” with a range of possible combinations of sensitivities and specificities to examine risk assessment. Our HIRC is similar to Mossman’s future violence test (FVT) in that it has equally high sensitivity and specificity for detecting each of the adverse events being considered. The HIRC differs from the FVT in that it has a single optimal sensitivity and specificity. This threshold was chosen as a way of examining risk assessment because, in practice, a cutoff score must be set for every instrument. We acknowledge that the highest proportion of correct classifications depends on both the base rate of predicted events and the sensitivity and specificity of the risk categorization. For example, the choice of a sensitivity and specificity to optimally predict a rare event such as homicide, rather than a common event such as minor assault, has to consider the

### Definitions of Sensitivity, Specificity, and Positive Predictive Value

$$\begin{aligned} \text{Sensitivity} &= \text{proportion of actual positives that are correctly identified} \\ &= \frac{\text{True positives}}{\text{True positives} + \text{False negatives}} \end{aligned}$$

$$\begin{aligned} \text{Specificity} &= \text{proportion of negatives that are correctly identified} \\ &= \frac{\text{True negatives}}{\text{True negatives} + \text{False positives}} \end{aligned}$$

$$\begin{aligned} \text{Positive predictive value} &= \text{proportion of test positives that are true positives} \\ &= \frac{\text{Sensitivity} \times \text{Prevalence}}{\text{Sensitivity} \times \text{Prevalence} + (1 - \text{specificity}) \times (1 - \text{prevalence})} \end{aligned}$$

**Contingency Table: Risk Categorization Versus Future Harm**

	<b>Categorized as low risk</b>	<b>Categorized as high risk</b>
<b>Harm would not have occurred</b>	True negatives	False positives
<b>Harm would have occurred</b>	False negatives	True positives

frequency of these events. Hence we chose optimal values for sensitivity and specificity that were equal and that exceeded the sum of the sensitivity and specificity values found in any published study of future harm in psychiatric populations over any time frame.

### Positive Predictive Value of Risk Categorization

Using the estimates for the incidence of adverse events in psychosis and the proposed levels of sensitivity and specificity of the HIRC, we estimated the proportion of patients with a positive test result that would be true positives—the positive predictive value—using established methods. The inverse of this value can be viewed as the number of high-risk categorizations needed to correctly predict a single adverse event, termed the *number needed to predict* (NNP). This measure is analogous to the more familiar *number needed to treat* (NNT). NNP represents the number of people categorized as high risk and subject to individual risk management for the period of treatment required to reduce risk, in order to prevent a single adverse event. The model assumes that individual risk management always prevents the predicted harm, an assumption that is overly optimistic if one considers the results of attempts to prevent rare, but catastrophic, events such as suicides among psychiatric inpatients.

## RESULTS

Rates of homicide and of homicide of strangers by people with psychosis were derived from two recent meta-analyses. Studies reporting rates of attempted suicide, assault, and criminal conviction for violent offenses by patients with treated and never-treated schizophrenia were readily located. When a meta-analysis of rates was not available, estimates of rates were made using the middle value reported in the included studies (Table 1).

We located three studies that reported the optimal sensitivity and specificity of risk-assessment instruments in cohorts of patients with psychosis, and five studies of the application of those instruments on cohorts of psychiatric patients (Table 2). Sensitivity (true-positive rate) of 80% and specificity (true-negative rate) of 80% were chosen for HIRC because one study—of short-term predictions of suicide<sup>45</sup>—achieved this degree of accuracy. Studies report-

ing a sensitivity higher than 80% had much lower specificity, and vice versa. Using sensitivity and specificity of 80%, along with the base rates of seven adverse events in schizophrenia, we calculated the positive predictive value and the number of high-risk categorizations per true-positive prediction of harm (Table 3). As an example, we calculated that in order to prevent one homicide of a stranger, 35,000 high-risk patients with schizophrenia would require completely successful individual risk management.

## DISCUSSION

Dichotomous risk categorization of patients results in four possible outcomes: true positives, false positives, false negatives, and true negatives (see text box above).

### The Consequences of Risk Categorization upon True-Positive Cases

Patients categorized as high risk who would have gone on to commit or experience future harms might benefit from the additional treatment and containment provided as a result of individual risk management. In actual clinical practice, however, not all of these patients would benefit, because the additional intervention would not prevent *every* adverse event. People still commit suicide in hospital, and patients receiving compulsory community treatment still commit assaults. Nevertheless, in a proportion of cases in which the potential harm has been correctly predicted, the harm might be prevented by an intervention derived from correct categorization on the basis of risk.

### The Consequences of Risk Categorization upon False-Positive Cases

Depending on the type of adverse event, patients categorized as high risk, but who would not commit or experience future harm, account for 50% to 99.97% of high-risk patients detected by the HIRC. Under risk categorization, these false-positive patients would receive additional interventions, such as longer detention and involuntary treatments. However, as these patients are false positives, no reduction in future harm would result. Some patients might receive an incidental therapeutic benefit from individual

**Table 1. Published Estimates of Rates of Adverse Events Associated with Schizophrenia**

Adverse event	Study	Type of study	Rate	Estimated rate <sup>a</sup> of adverse event
Homicide of a stranger	Nielssen et al. (2009) <sup>21</sup>	Systematic review & meta-analysis	1 in 140,000 per annum	1 in 140,000 per annum
Homicides after treatment	Nielssen & Large (2010) <sup>22</sup>	Systematic review & meta-analysis	1 in 10,000 per annum	1 in 10,000 per annum
Homicide before treatment	Nielssen & Large (2010) <sup>22</sup>	Systematic review & meta-analysis	1 in 630 patients	1 in 630 patients
Suicide	Newman & Bland (1991) <sup>23</sup>	Longitudinal study	1 in 370 per annum	1 in 200 per annum
	Limosin et al. (2007) <sup>24</sup>	Longitudinal study	1 in 250 per annum	
	Ran et al. (2007) <sup>25</sup>	Longitudinal study	1 in 243 per annum	
	Loas et al. (2008) <sup>26</sup>	Longitudinal study	1 in 200 per annum	
	Carlborg et al. (2008) <sup>27</sup>	Longitudinal study	1 in 167 per annum	
	Alaraisanen et al. (2009) <sup>28</sup>	Longitudinal study	1 in 110 per annum	
Attempted suicide in first episode schizophrenia	Johnstone et al. (1986) <sup>29</sup>	Cohort of first-admitted schizophrenia	1 in 4 patients	1 in 5 patients
	Nordentoft et al. (2002) <sup>30</sup>	First-presentation psychosis	1 in 5 patients	
	Addington et al. (2004) <sup>31</sup>	First-presentation psychosis	1 in 7 patients	
	Payne et al. (2006) <sup>32</sup>	First-presentation psychosis	1 in 5 patients	
Assault in first episode schizophrenia	Humphreys et al. (1992) <sup>33</sup>	Cohort of first-admitted patients	1 in 7 patients	1 in 7 patients
	Volavka et al. (1997) <sup>34</sup>	First-presentation schizophrenia	1 in 10 patients	
	Steinert et al. (1999) <sup>35</sup>	First-presentation schizophrenia	1 in 7 patients	
	Bhugra et al. (2000) <sup>36</sup>	First-presentation schizophrenia	1 in 7 patients	
	Harris et al. (2010) <sup>37</sup>	First-presentation psychosis	1 in 4 patients	
	Lindqvist & Allebeck (1990) <sup>38</sup>	Case linkage	1 in 500 per annum	
Conviction for violent offense	Munkner et al. (2003) <sup>39</sup>	Case linkage	1 in 50 per annum	1 in 100 per annum
	Wallace et al. (2004) <sup>40</sup>	Case linkage	1 in 166 per annum	
	Soyka et al. (2007) <sup>41</sup>	Case linkage	1 in 250 per annum	
	Walsh et al. (2004) <sup>42</sup>	Longitudinal study after discharge	1 in 8 per annum	
Any assault by treated patients	Swanson et al. (2006) <sup>43</sup>	Longitudinal study after discharge	1 in 13 per annum	1 in 10 per annum

<sup>a</sup>Assumes a prevalence for schizophrenia of 1%.

**Table 2. Published Estimates of Sensitivity and Specificity of Risk-Assessment Tools and Research Methods**

Adverse event	Study	Patient group	Sensitivity	Specificity
Suicide	Pokorny (1983) <sup>44</sup>	Admitted patients	56%	74%
	Motto & Bostrom (1990) <sup>45</sup>	Psychiatric patients	79%	81%
	Goldstein et al. (1991) <sup>46</sup>	Affective disorder	2%	99.7%
	Taiminen et al. (2001) <sup>47</sup>	Schizophrenia	74%	71%
Self-harm & suicide attempts	Cooper et al. (2006) <sup>48</sup>	Emergency department	94%	25%
	McMillan et al. (2007) <sup>49</sup>	Meta-analysis Beck Hopelessness Scale	78%	42%
Assault	Arango et al. (1999) <sup>50</sup>	Schizophrenia	50%	95%
	Monahan et al. (2005) <sup>20</sup>	Discharged patients	70%	77%
	Wootton et al. (2008) <sup>51</sup>	Psychiatric patients	66%	71%
	Harris et al. (2010) <sup>37</sup>	Early psychosis	26%	78%

**Table 3. Positive Predictive Value for the Detection of Adverse Events in Schizophrenia<sup>a</sup>**

Event	Period of illness	Base rate	PPV	NNP <sup>b</sup>
Attempted suicide	Before any treatment	1 in 5	50%	2
Assault	Before any treatment	1 in 7	40%	2
Assault	Annual rate after treatment	1 in 10	30.8%	3
Violent crime	Annual rate after treatment	1 in 100	3.9%	26
Suicide	Annual rate after treatment	1 in 200	2.0%	50
Homicide	Before any treatment	1 in 600	0.66%	151
Homicide	Annual rate after treatment	1 in 10,000	0.040%	2500
Stranger homicide	Annual rate of stranger-homicide	1 in 140,000	0.0029%	35,000

<sup>a</sup>Predicted with a hypothetical instrument for risk categorization that has both a sensitivity and specificity of 80%.

<sup>b</sup>Nearest integer.

NNP, the number of high-risk categorizations needed to predict a single adverse event; PPV, positive predictive value.

risk management via the additional resources devoted to their care, but the high-risk categorization is likely to result in restricted liberty and additional stigma. Patients who are subject to false-positive predictions of self-harm shoulder the burden of risk for other patients in the sense that true positives cannot receive individual risk management without a group of false positives also receiving the same intervention. In the case of patients deemed to be at risk of harm to others, those patients subject to false-positive predictions of risk carry the burden of risk for the benefit of the whole community. In theory, the number of false positives can be reduced by using higher cutoff scores, but that change would inevitably result in a greater number of false-negative risk categorizations—which would diminish harm reduction, the justification for risk assessment.

### The Consequences of Risk Categorization upon False-Negative Cases

The HIRC has a sensitivity of 80%. Hence, one-fifth of patients who subsequently commit or experience a harmful event would have been categorized as low risk. The mental health laws of many countries do not allow ongoing non-consensual treatment of patients incapacitated by mental illness unless they are also judged to present a risk of future harm to themselves or others. In these circumstances, patients wrongly categorized as being at low risk might be

deprived of needed care, even though they might well have agreed to the treatment had they been competent to recognize their need for it. That treatment could, in turn, have prevented the adverse events. Although false negatives can be reduced by using a lower cutoff score to define high-risk groups in actuarial models, this change inevitably would result in more false positives.

### The Consequences of Risk Categorization upon True-Negative Cases

True-negative categorization has the potential to affect a large proportion of patients because only a minority of patients experience adverse events or threaten to harm themselves or others. The potential harm to this group stems from the absence of any benefit to the patient or to the community from the exercise of risk assessment, and from the likelihood that patients placed in this group will receive less psychiatric care as a direct result of a low-risk categorization. In mental health systems that use risk categorization to guide allocation of resources or to decide upon nonconsensual treatment, all low-risk patients, including those who would have the capacity to consent to treatment were it not for their untreated illness, could be deprived of care because they are classified as low risk.

## CONCLUSIONS

This examination of the limitations of risk categorization shows that an inevitable consequence of risk assessment is that a large number of patients who will not go on to cause or experience harm will nevertheless be classified as being at high risk of harm, even if they were assessed using instruments that were substantially more versatile and accurate than those currently available. This finding is especially salient for rare events with serious consequences, such as suicides, serious violence, and homicides. The smallest number of false-positive categorizations per true-positive prediction is among people with never-treated schizophrenia. However, patients in their first episode of psychosis are unlikely to be the subject of risk assessment until they are in contact with mental health services, at which time they are likely to benefit from treatment regardless of their perceived level of risk. The high probability of false categorization suggests that individual risk-management strategies, defined as individual treatment measures instituted solely on the basis of the patient being classified as high risk, should be restricted to interventions that have few negative consequences for the individual and that would be beneficial to most patients. Examples of such interventions include more intensive treatment for substance abuse, counseling aimed to reducing interpersonal conflict and deficits in social

skills, and increased support in the areas of accommodation and financial management. By contrast, because of the large numbers of false predictions, especially for rare and serious events, coercive and potentially harmful measures should not be instituted solely on the basis of risk categorization.

Although it would be possible to reduce the number of false predictions by increasing the threshold for high-risk categorizations, the inevitable result would be a higher number of missed cases. Furthermore, although more common, but less serious, harmful events can be predicted more accurately, even the best forms of risk categorization have a high number of errors, with the consequence that they do not provide an adequate justification for individual risk-management strategies that have significant and unwanted consequences for patients. That said, a consequence of a low-risk categorization might be that mental health services do not provide patients with needed treatment, such as voluntary hospital admissions or involuntary treatment for conditions that could respond to treatment.

It might be argued that the process of risk assessment has value irrespective of the outcome of risk categorization, because it serves to remind clinicians to consider the patient's entire history and the symptoms or situations that might have resulted in previous violence. However, a thorough clinical assessment does not require a risk categorization, which is, in effect, a guess as to the patient's future conduct. The use of risk categorization by a clinician or service can also be the source of harmful criticism in the wake of an adverse event involving a patient categorized as low risk. We agree with the observations of Mossman about the negative consequences of risk assessment for the way that clinicians view their patients, and believe that proper consideration of the patient's situation, symptoms, strengths, and disabilities will be better for patients than attempting to predict their future conduct. Moreover, risk assessment and categorization have tangible opportunity costs—in particular, the time taken by highly trained specialists to undertake risk assessment, which is time better spent on other aspects of treatment such as building rapport, managing substance abuse, encouraging adherence to medication, and checking on any arrangements that have been made for discharge or for the transfer of the patient's care.

Observations about the scientific limitations of risk assessment are not new, but these criticisms have not discouraged the huge growth in research in this area or the adoption of routine risk assessment in general adult mental health services, where serious adverse events are rare. It may be that clinicians continue to believe in the value of risk assessment and categorization because the mathematical concepts are difficult to grasp. Clinicians might also be reinforced in their view of the effectiveness of risk assessment simply because false-negative predictions of serious harms are rare (as a result of the low base rate for these events), and false

positives and true positives cannot be distinguished if clinicians assume that treatment to reduce harm is effective. Another important factor to be considered is the effect of media scrutiny of adverse events and the difficulty explaining to legal enquiries (of various sorts), mental health administrators, the relatives of victims, and even the general populace why many of these frightening events cannot be predicted.

Despite the growing acceptance of risk assessment and categorization, our hypothetical analysis using the epidemiology of adverse events in schizophrenia shows that risk categorization is a flawed way of making decisions about risk-management strategies for individual patients. Even if there were versatile, sensitive, and specific instruments such as the hypothetical instrument described in this study, they would be of limited assistance because of the low base rate of the most serious adverse events and the absence of distinguishing features of patients who go on to commit serious harm.

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