DETECTING, CORRECTING AND INTERRUPTING ERRORS

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I. INTRODUCTION and THEORY

A "medical error" is not a MEDICAL error; it is a medical ERROR. An error made in a hospital is a behavioral event not a medical one; and the science of human behavior is psychology. Nurse or physician errors in a hospital are very much like pilot errors in aircraft or operator errors in a nuclear power plant. They differ only in terms of the environments in which they occur.

Errors are more frequently made than forgiven; and that is also something for the psychologist to examine. It is a folk myth that people who make errors are careless, or stupid, or idiots, or fools. The reality is quite different. Highly skilled people will make errors - to err is indeed human despite a determination to avoid error. Yet people are consistently held accountable for their errors when they lead to undesirable outcomes. Is this proper? I argue that it is not; one should not be held accountable for acts of God. The American College Dictionary defines Act of God thus: "In law; a direct, sudden, and irresistible action of natural forces, such as could not humanly have been foreseen or prevented." Errors are direct, sudden, and irresistible events. No one plans an error; no one expects an error; no one lets an error happen. An error is a Mental Act of God (MAOG).

What do we know about errors? In truth not very much, and certainly not as much as we should know. We can give some partial answers to a number of fundamental questions about errors.

II SOME IMPORTANT QUESTIONS

What is an error? From the external viewpoint, an error is a failure to perform an intended action which would have been correct given the circumstances. In my view an error can occur only if there was or should have been an appropriate intention to act on the basis of a perceived or a remembered state of events; and if the action finally taken was not that which was or should have been intended.

An error is not defined by an adverse or serious outcome. An adverse outcome may occur with no error if the intention was the proper one, the action was properly executed, and the outcome was probabilistic in nature (as in playing a game, in deciding whether to carry an umbrella, or in performing an operation or administering a medication known to be risky.)

Can we predict when an error will occur? All the experimental evidence suggests that we cannot. Statistical analysis of the times when errors occur strongly support the conclusion that errors are random events in time. They are somewhat like radioactivity - we can say what the mean interval between events will be but we cannot predict when an event will happen.
Can we predict what form an error will take? The answer to this query is more promising. Theory says that if we carefully analyze the tasks and the circumstances in which tasks are performed - an Intensive Care unit for example - we can predict the likely forms of errors which will occur if an error occurs at all (since we do not know whether any error will occur in any interval of time).(1)

Can errors be voluntarily controlled? Probably only to a slight degree. It may be that the probability of error can be consciously altered although not over a long time interval. Or it may be that one can reduce errors in one time interval only to have them crop up at some other time. There needs to be more research before we can answer this important question.

Are some people more likely to make errors than other people? The question of error-proneness has not been answered. It used to be thought that error-proneness existed. Then it was thought that it did not. The folk myth persisted nonetheless. It is my present view that with respect to probability of error there are differences between people and there are differences between any person at one time and the same person at another time.

How can one control one's own errors to avoid accidents? Probably the best way is to improve the probability of detecting one's own errors and correcting them before they are completed. There is evidence that training can improve such self-detection even if it does not improve the underlying error rate.(2) It is certainly the case that improved design of medical objects can be very helpful.(See part III)

Why do errors happen? An error is a psychological event with psychological causes if errors are caused at all. There is always the possibility that the causes of all or some errors can not be identified. An error may have any of a possibly large number of causes. There is always the possibility that some errors are uncaused.

III TAXONOMIES OF ERRORS

Any defined hypothetical causal mechanism can give rise to a taxonomy or classification system of errors. Since there are many hypothetical causal mechanisms there are many causal taxonomies of error.(2) Here are some of them:

Psychological processes
Input error or misperception: the input data are incorrectly perceived, an incorrect intention is formed, and the wrong action is performed, that is, an action other than what would have been intended, had the input been correctly perceived. For example, I may be confronted by the phrase "1000 mg" and see it as "100.0 mg". I decide that it should be administered as a bolus into a Y-
port and I successfully do so. A fatal overdose of 1000 mg results.

**Intention error or mistake**: the input data are correctly perceived, an incorrect intention is formed, and the wrong action is performed, that is, an action other than what should have been intended given that the input was correctly perceived. For example, I may be confronted by the phrase "1000 mg" and see it as "1000 mg". I incorrectly decide that it should be administered as a bolus into a Y-port and I successfully do so. A fatal overdose of 1000 mg results.

**Execution error or slip**: the input data are correctly perceived, the correct intention is formed, and the wrong action is performed, that is, an action other than what was intended. For example, I may be confronted by the phrase "1000 mg" and see it as "1000 mg". I correctly decide that it should be administered as a drip after dilution in a drip bag. I become distracted while approaching the patient and, from habit, inject the contents as a bolus into a Y-port. A fatal overdose of 1000 mg results.

Note that the external appearances of the three very different errors are identical.

**Location**

**Endogenous error**: these errors arise from processes inside the actor. The elimination or reduction of such errors must involve psychology, physiology or neurology. The error resulting from distraction cited above is endogenous. It probably results from the capture of a lower probability process (injection into a bag) by a higher probability process (injection into a Y-port), the two processes sharing common elements of action.

**Exogenous error**: an error which arises from processes outside the actor. The elimination or reduction of such errors must involve engineering and design of objects and work environments. The error may arise from the occasional use of extraneous ".0" since this allows the false interpretation of "2000" as "200.0". Better yet, the probability of error could be reduced by the spelling out of the amount as "TWO THOUSAND" since this will rarely, if ever, be read as TWO HUNDRED."

It can be difficult to decide which of these categories an error belongs in but the distinction is useful as a conceptual tool.

**Mode**

If an error results in an action, then there is a phenomenon which can be observed. The particular appearance of the error we may call its mode. There are many possible descriptors of mode but a reasonably familiar set of error modes is:

**Omission**: an error characterized by the leaving out of an appropriate step in a process.

**Insertion**: an error characterized by the adding of an inappropriate step to a process.
Repetition: an error characterized by the inappropriate adding of a step normally appropriate to a process. (This may be reduced to the insertion of a step which would ordinarily be appropriate.) Substitution: an error characterized by an inappropriate object, action, place or time instead of the appropriate object, action, place or time. (This may be reduced to an omission followed by an insertion of some other step).

IV. ERRORS IN THE MEDICAL SETTING

The study by Leape, et al (3) is a good data source. Leape evaluated 30,195 randomly selected records from 51 hospitals in the state of New York. The initial screening was aimed at identifying adverse events. Of the 30,195 examined some 1133 patients (3.7%) were found to have "disabling injuries caused by medical treatment." These adverse outcomes were then classified in various ways. Of interest here are the findings that 178 of the adverse events, or 19.4%, resulted from drug complications; these were the most common type. The subgroup not involving operative procedures had 534 events in total so that the actual rate of drug-related adverse outcomes was 178/534 or one third. Medication errors were the largest single problem found in this study. Similar results were obtained more than a decade earlier by Wang (4).

If we set aside the 41% of events which occurred in operating rooms, we find that the majority of the remainder, 26.5% of the total in the hospital, occur in the patient's room. The report does not identify in detail what was done to produce the adverse outcome but we can easily guess that patients were on occasion given the wrong medication, the wrong dosage, by the wrong channel, or any of a variety of possible failures of the system.

The rates found by Leape cannot be used to estimate the probabilities of error. Leape saw only those errors which resulted in injury or death - that is to say - he saw only the accidents. This is a general problem for the investigator trying to improve designs, procedures, and policies. The number of accidents involving Lidocaine, for example, is an interesting statistic but it does not tell us much about why the errors occurred or how many occurred. We do not see those errors which were caught before they were completed. As a consequence we do not have a good estimate of the probability of substitution errors on the night shift, or by physicians, or by pharmacists. If we did we might be able to draw some important conclusions about product design, pharmacy practice, optimal work/rest shifts for hospital personnel, and a great many other things as well. The mode of an error is a datum of great importance. It could, for example, help us in estimating the risk of the introduction of a new drug, a new package, or a new device into the hospital. Good data about errors are needed.
V. SOME PRACTICAL SUGGESTIONS

Self-detection and correction
An error can occur, and can be self-detected and corrected at many points in the sequence of mental events between a perception or decision and the resulting action. An error can occur, and can be self-detected and (sometimes) corrected, at many points in the sequence of physical events between the beginning and the end of an action. Such error detection can be of the error's mode, of its expression, or of its consequence. For example, a nurse may start to reach for a 2 gram Lidocaine syringe and change the motion towards its correct goal, the 100 mg syringe. This correction might be a conscious act or not; little has been done on the analysis of incipient errors. A nurse may actually pick up the wrong syringe and replace it with the correct one, and so on. There are many opportunities for self-detection. Personal experience tells us that the probability of such self-corrected errors will be high, and that such errors are common. Some recent data gathered by Senders and Cohen (5) suggest that for every error completed by nurses (for example, the use of a wrong syringe) there may be ten which were caught before they actually were completed, so that there was no accident and, therefore, no report. Errors are much more likely than we might think on the basis of data from present reporting systems.

Change in behavior
For mental events, possible remedial actions must be psychological in nature. Sellen, for example, suggests the possibility of training in the use of tactics leading to improved probability of self-detection of error.(2) One theory of capture errors would suggest that if one were to maintain one's intention in explicit form the probability of a substitution error would be reduced. This would mean that instead of "read the label; read the label; read the label" the instruction should be "tell yourself what you are planning to do; tell yourself what you are planning to do; tell yourself what you are planning to do."

Is the instruction to read the label three times really useful as ordinarily presented? It might be better if one were to read the label while holding the pharmaceutical in one hand and then to read it again after putting it down and picking it up with the other hand. The principal reason why this suggestion should help is that the second reading is more likely to be independent of the first. Only if the successive readings are relatively independent does it do any good to make them. Part of the independence stems from the fact that the positions of the fingers on the label will be different so that blocking a critical part of the printed message is less likely to occur in the same way on successive occasions. Finally one may speculate that there is some effect on the perception of the printed message as a result of handling the package with a different hand.
Error and the failure to detect one's error are induced by familiarity with procedures and materials coupled with a regrettable tendency on the part of human beings to perceive confirming evidence more readily than disconfirming evidence. We tend to see what we want to see rather than what there is to see. This is why the putting down and picking up again with a different hand is useful. The changes of both tactual and visual aspects should reduce the effects of expectation.

Change in design
There needs also to be appropriate design of the elements of the system and the system as a whole. The goal of such design: of the use, the packaging, the labeling, the warnings, is to make the object announce its identity to the user through many independent and redundant routes. A medication container should tell the person holding it what its name is, what the appropriate dose is, how it should be used, and what the consequences will be if it is used in any of a variety of improper ways. And it would say all this in multiple ways, clearly and unambiguously.

Finally, one must accept the fact that various errors will occur and try to prevent or inhibit the translation of the error into an accident. The Food and Drug Administration and the manufacturers must stop expecting nurses and physicians to use things correctly every time. One must ask:

What incorrect actions can people do?
What will be the result of the incorrect actions?
How can we prevent those actions from being completed?

That is, if a possibility has undesirable consequences, then the possibility must be eliminated.

Change in policy
Blame implies that incipient errors can be perceived by the actor before they are executed, and can be voluntarily controlled to prevent their execution. Responsibility implies that consequences arise because of flaws in character or behavior.

Risk to the patient could be reduced by establishing a nonblaming, indeed a rewarding, environment to encourage the reporting of error even if there were no adverse outcome. If data could be gathered for all errors in all hospitals, it would be possible to learn the relative frequencies, and possibly the probabilities, of different kinds of error, and to identify the problems before a patient is injured. Such a database would be of inestimable value if the reporting system were correctly organized.
VI. REFERENCES


6) Senders, J., Theory & Analysis of Typical Errors in a Medical Setting, Hospital Pharmacy, 28 (6), June, 1993.

ADDITIONAL RECOMMENDED READING