A Probabilistic Approach to Underwriting Suspected Alcohol Abuse

By Richard E. Braun, MD, FLMI
Medical Director
Lincoln National Life Insurance Company
Consultant, Lincoln National Risk Management, Inc.
Ft. Wayne, Indiana

Before you read this article please take a moment to consider a case. An application for life insurance in the amount of $500,000 on a 50 year old male is brought to your attention because of an abnormal GGT. The GGT is 99 U/L, and the remainder of the lab work is normal. The MVR is not available and the Inspection Report is benign. The APS is brief with the following salient points: An MCV of 95 cubic microns; he was injured in an altercation last New Year’s Eve; and he reported to his attending physician that he drinks “4 beers a day.” How would you rate this case? Would your colleagues arrive at a similar rating? If not, why not? Could an expert system improve the consistency and quality of classifying the risk in this uncertain situation?

Introduction

Development of expert systems to underwrite medical impairments has caused us to take an in depth look at the reasoning process underlying an underwriting decision. This article will outline the types of problems that an underwriter (or Medical Director) might encounter, the reasoning methods currently used, and an approach to quantitate a risk in the face of a particular underwriting dilemma.

Basically, the underwriter faces two types of questions when considering medical impairments. 1. How severe is a known impairment (what is the mortality risk of someone known to have Crohn’s disease)? 2. What is the likelihood that a proposed insured has a particular disease (an APS or an abnormal lab result has led you to consider a particular impairment, but there is no firm diagnosis)? The first type of question is addressed quantitatively by the construction of mortality monographs. There are situations when uncertainty exists for Type 1 questions, but these are generally due to the lack of adequate information in the particular underwriting file or combination of known (Type 1) impairments. In this article, however I will address the Type 2 question.

The thought processes utilized when considering a proposed insured who may have an undiagnosed abnormality are similar to those used in making a medical diagnosis in clinical practice. However, the medical underwriter’s situation is more constrained and unique. First, there is an economic incentive for the proposed insured to trivialize or omit medical history. Second, the facts obtained are often brief and/or illegible. Finally, the underwriter’s ability to gather more information is severely restricted by time limitations and monetary considerations.

The Deterministic Approach

Currently the medical underwriter takes a deterministic or rule based approach to evaluating suspected, undiagnosed impairments. An example of such a rule would be “If the applicant’s stress ECG shows 1.5 mm of ST depression, then add 75 debits.” Such general rules are meant to reflect the possibility that the applicant may have a significant medical impairment as well as taking into account that impairment’s impact on mortality. Basic rules are derived largely from past experience, didactic learning, and reading of medical literature. The medical director is valuable in this rule-formulating capacity due to the extent of his underlying medical knowledge and practical experience. The lay underwriter is at a disadvantage in this capacity because of the lack of pertinent feedback concerning his “diagnostic decisions.”

Potential sources of error associated with rule-based reasoning in the setting of medical diagnosis have been identified by investigators in the field of cognitive psychology. These are discussed below to provide insight into the wide variation of opinion that occasionally occurs on a particular underwriting case.

Representativeness — This is the assigning of risk based on how closely the case under consideration resembles a larger parent population. For example, when considering the likelihood that a particular proposed insured is alcohol dependent, you might compare the features of the case to the description of alcoholism from medical texts. The closeness of fit would then determine your estimate of the probability of alcoholism. Sources of error in using the representativeness heuristic would include the following:

1. Placing too much emphasis on clinical clues that do not accurately predict disease. This could occur when considering an applicant with suspected pulmonary embolus history. Any defect on a perfusion lung scan might be mistakenly considered as strong evidence that there was an embolus. However, the specificity of very small defects on lung scan has been reported as 4%, which means that 96% are false positives.

2. Failing to consider the underlying prevalence of disease. We see this frequently in the cases with chest pain, risk factors for coronary disease, and a negative stress test. Chest pain that is anginal in nature identifies a group with a high prevalence of coronary artery disease. Stress tests have as
much as a 40% false negative rate (60% sensitivity). And yet we still see cases rated preferred in this situation. Part of the problem is failure to consider the higher prevalence of coronary disease in applicants with chest pain. In defense of underwriters, they often get the view that coronary disease has been ruled out from the attending physician.

3. **Using personal experience from a small group of patients as the representative group.** A physician may have only had experience with renal patients in a tertiary care (university hospital) setting. Patients are often referred to this type of clinic because they have severe disease, are clinically difficult to manage, or are economically disadvantaged. This may cause the physician to overestimate the mortality risk of renal disease when he compares an underwriting case to this non-representative group.

**Availability** — This is the tendency to judge the probability of disease based on how easily the situation is remembered. We can easily recall recent events, rare events, and unpleasant outcomes. For example, you review an early claim on a very large case you approved. The cause of death was Lung Cancer, and the only medical history at the time of underwriting was recent phlebitis. If you are later considering a similar situation the tendency is to overestimate the importance of phlebitis and you will have difficulty taking the same action without ordering additional tests.

**Anchoring and adjusting** — These terms describe the initial estimate of probability of disease and later changes of that estimate based on new information, respectively. The tendency is to anchor near the extremes (to think that there is a high likelihood that disease is present in a given case, absent in another). And there is a conservative tendency to underadjust and stay with the initial estimate despite new information. As an example a 50 year old man with atypical angina has approximately a 0.55 probability of having coronary disease, but most would tend to categorize him into either a disease or no disease group.

**The Probabilistic Approach**

A method of quantifying diagnostic uncertainty has been suggested, and used extensively in interpreting stress test results.\(^{45}\) It is based on Bayes' Theorem on conditional probability, and allows us to calculate an overall (posterior) probability that the proposed insured has disease. Bayes' Theorem can be stated in a clinically useful form as:\(^2\)

\[
\begin{align*}
\text{probability of disease} & = \frac{p[D] \times \text{sensitivity}}{[p[D] \times \text{sensitivity}] + ([1-p[D]] \times (1-\text{spec}))} \\
\text{probability of disease} & = \frac{p[D] \times (1-\text{sensitivity})}{[p[D] \times (1-\text{sensitivity}) + ([1-p[D]] \times \text{spec})]}
\end{align*}
\]

Where \(p[D] = \text{pretest probability of disease, sensitivity of the test is true positives/people with disease, and spec (specificity) is true negatives/people without disease.}\)

An illustration of this approach can be constructed for suspected diagnosis of alcohol dependence. This approach is not meant to disprove deterministic reasoning. However, it can augment the rules we form and provide a statistical method of emulating our thought processes.

Initially a prior probability or prevalence of alcohol dependency that matches the insured population as closely as possible should be delineated (Figure 1). These prevalence statistics were taken from a general population survey that required a response and an interview, making it less likely to include the "skid row" type alcoholic (more like an insured population).\(^6\)

Also on the initial graph is a line representing those who admit to \(\geq 4\) drinks per day (Figure 1). This can be calculated from the sensitivity and specificity of admitting to drinking \(\geq 4\) drinks per day.\(^7\)

![Figure 1](image_url)

**Figure 1**

**Alcohol Dependence**

**Men**

This graph represents the prior probability of alcohol dependence in men based on age and admitted drinking habits.\(^57\)

Other independent factors that might indicate alcohol dependence and that are often available on an underwriting file include GGT, MCV, and pertinent medical history. Again using sensitivities and specificities obtained from the medical literature (Table 1) graphs can be constructed to illustrate the corresponding posterior probability for the range of prior probabilities 0 to 1. This is done by plugging the appropriate sensitivity and specificity and the prior probabilities 0 - 1 into Bayes' Theorem, and calculating the corresponding posterior probabilities (Figures 2,3,4). Note that the axes of Figure 3 have been reversed to facilitate construction of a nomogram (Figure 5).
**Table 1**

<table>
<thead>
<tr>
<th>Finding</th>
<th>Sensitivity % ± 1 SEP*</th>
<th>Specificity % ± 1 SEP*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinks ≥ 4 drinks/day⁷</td>
<td>47 ± 10.6</td>
<td>96 ± 1.5</td>
</tr>
<tr>
<td>GTT (U/L)⁶</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 - 50</td>
<td>41 ± 8.4</td>
<td>11 ± 11</td>
</tr>
<tr>
<td>51 - 100</td>
<td>22 ± 9.7</td>
<td>91 ± 3.6</td>
</tr>
<tr>
<td>101 - 200</td>
<td>15 ± 10.3</td>
<td>99 ± 1.2</td>
</tr>
<tr>
<td>≥ 201</td>
<td>22 ± 9.7</td>
<td>99 ± 1.2</td>
</tr>
<tr>
<td>MCV ≥ 96⁸</td>
<td>73 ± 5.7</td>
<td>60 ± 7.6</td>
</tr>
</tbody>
</table>

Injured in a fight or assault after age 18⁹ |

<table>
<thead>
<tr>
<th>Sensitivity % ± 1 SEP*</th>
<th>Specificity % ± 1 SEP*</th>
</tr>
</thead>
<tbody>
<tr>
<td>49 ± 4.4</td>
<td>92 ± 2</td>
</tr>
</tbody>
</table>

* standard error of the percent = square root of pxq/n, where p=the percent expressed as a decimal, q=1-p, and n = number of patients.⁴

---

**Figure 2**

GGT Level

This graph depicts the posterior probability of alcohol dependence based on prior probability 0-1 and the sensitivity and specificity of various levels of GGT (U/L) for alcohol dependence.⁵

---

**Figure 3**

MCV

This graph depicts the posterior probability of alcohol dependence based on prior probability 0-1 and the sensitivity and specificity of MCV ≥ 96 fl for alcohol dependence.⁶ Note that the axes are reversed to facilitate construction of a nomogram.

---

**Figure 4**

Injured in Fight after age 18

This graph depicts the posterior probability of alcohol dependence based on the prior probability 0-1 and the sensitivity and specificity of being injured in a fight (after age 18) for alcohol dependence.⁷
The various graphs can be arranged so that a line through the posterior probability on one graph will correspond to the prior probability of the next. This is simply a graphic representation of what can be accomplished with expert systems.

The nomogram can then be used to consider our underwriting case.
Case Review

A 50 year old man applies for $500,000 of insurance. His GGT is 99 U/l. His APS reveals a MCV of 95 cubic microns done in the past year. He was also injured in an altercation last New Year's eve. His drinking habits are described as "four beers a day" in the APS (see Figure 6).

Start by locating the person's age. Then locate the corresponding value on the line that most appropriately identifies drinking habits. Draw a perpendicular line to the x axis, this point is the initial or prior probability of alcohol dependence (.35. Extend this line onto the GGT graph until it intersects the line that reflects the person's GGT level. Draw a perpendicular line. The point where this intersects the y axis (.37) represents the initial posterior probability for alcohol dependence. By extending this line onto the MCV graph the posterior probability (GGT) becomes the prior probability for the next factor (MCV). Intersect the line representing the appropriate MCV and draw a perpendicular to locate the posterior probability of alcohol dependence based on age, drinking history, GGT, and MCV (.37). This line can then be extended onto the graph labeled Injured in Fight. Intersect the appropriate line and draw a perpendicular. The point of intersection with the y axis is the final posterior probability of alcohol dependence based on age, drinking history, GGT, MCV, and whether or not the person was injured in a fight (.80). If some information is not known the corresponding graph should be omitted from consideration and the final probability would be based on the information that is known.

![Figure 6](image-url)
Using the probabilistic approach results in a final probability of disease. But this probability must somehow be translated to a rating. As was already mentioned probability translates to prevalence (.3 probability is the same as 30 out of 100). So one could assume that given 100 proposed insureds with .3 posterior probability of disease 30 of them would have disease. It also seems logical that the higher the probability of disease (when probability is based on laboratory test results and clinical clues) the more likely that the disease is advanced. This has been documented in a paper that compares the posterior probability of coronary artery disease to catheterization findings.10

In the case of suspected alcohol dependence, current alcohol abuse would be uninsurable. But a debit is needed so let's assume that a blending of heavy drinkers and alcohol dependent proposed insureds are identified by the method and use a rating of 400%. Then using the example above the proposed insured had a posterior probability of alcohol dependence (heavy use) of .8, and a probability of no dependence of .2. The GGT and MCV graphs were derived from a study of hospitalized men. To compensate for the expected lower sensitivity and specificity in the insured population a correction factor of .15 will be subtracted from the posterior probability. The correction factor is based on the estimated posterior probability that should be considered standard (.25).

\[ 0.8 - 0.15 = 0.65 \]
Non-alcohol dependent individuals are assumed to have 100% mortality.

\[ 400 \times 0.65 + 100 \times 0.35 = 295\% \] (suggested rating Table 8)

The benefits of a probabilistic approach to underwriting are many. The foremost is consistency. Giving the above example to several different medical underwriters would result in a range of opinions as to the appropriate action. The consistency derives from the clear weight given to each clinical clue based on its sensitivity and specificity for the disease under consideration. This approach also illustrates the value of diagnostic tests.2 From the pretest probability one can see how much a positive result would change the likelihood of disease, and then decide if the test is indicated. And there is benefit from the graphic representation of clinical clues. Saying that being injured in a fight has a 49% sensitivity and a 93% specificity for diagnosing alcoholism does not have the same impact as seeing it represented graphically.9 Of course, expert systems technology would allow a large number of clues to be considered before arriving at the final probability and the ultimate rating.

There are potential problems with this approach. Any time that you extrapolate from the medical literature to underwriting, you encounter spectrum bias. The studies are rarely done on populations that we would consider typical of those applying for insurance. Usually that works in our favor. Because our screening processes exclude some individuals who are included in the medical studies, we tend to get better survival in an insured population. But, when working with sensitivity and specificity it is difficult to predict how these will vary from one population to another.2

Another fact must be remembered. This probabilistic method is only considering one disease at a time. If the elevated GGT is due to some other disorder (such as Chronic Active Hepatitis) that disease would not be considered by a narrow approach, this could result in the false assumption of alcoholism or the overlooking of the other cause. It would be necessary to devise a probabilistic approach to cover several different possible causes for a commonly occurring abnormality (elevated GGT).

In the particular example of alcoholism, some other problem areas arise. There is no “gold standard” to unequivocally make the diagnosis. The articles used in this example made the diagnosis by the subject's admission of the disease, questionnaire, or a combination of the two.5,7,9

To further confound the issue, you have to consider the dimension of time. It has been reported that as many as 20% of alcoholics achieve permanent abstinence without help.11 It would seem then that medical history and lab values would have to be recent to be considered significant.

Summary

The medical underwriter currently uses a set of rules to underwrite undiagnosed disease. Different interpretations of these rules may result in differing opinions and inappropriate ratings because of a failure to consider the prevalence of disease and/or faulty weighting of clinical clues. The probabilistic approach seems well suited to underwriting suspected medical conditions because it is based on reproducible probabilities and it allows consistency in ratings.

References