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The Limits of Prognostication

*Eric Chevlen**

I. INTRODUCTION

Medical statistics are, by definition, data concerning aggregates of people. Individual patients are, by definition, the opposite of aggregates. At first blush, then, it would seem unlikely that medical statistics could be very accurate in predicting the disease outcome in individual patients. Indeed, as will be shown below, no clinical study demonstrates the ability of physicians to precisely predict the survival outcome in individual cases in a non-trivial way.¹ More importantly, the inability of physicians to precisely predict outcome in individual cases is not simply a shortcoming in practice that could be overcome with more sophisticated technology even in theory. Either human survival is dependent to some extent on important random events, and is, therefore, unpredictable, or it is completely determinative. Even if it is completely determinative, however, the mathematics of chaos theory almost surely govern it and make individual prognostication at best a probabilistic affair.

All of the above may be little more than truism and would be of little social or medical import were it not for the effort of some referenda, legislatures, and courts to legalize physician-assisted suicide for, at least in the initial legislative iteration, terminally ill people. These legal forays against 2400 years of medical ethics seek to cull out a class of citizens who would no longer be the beneficiaries of state interest in maintaining their lives. Indeed, legalized physician-assisted suicide would create a class of people

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1. Predictions such as "all patients with this disease will die within 120 years" are mathematically precise but clinically trivial.

who uniquely qualify for dispatching from this life with state approval, and often at public expense.²

Under current law, state interest in maintaining life does not depend on the health of the citizen. The state forbids homicide and assisted suicide in healthy and sick alike. Legalization of physician-assisted suicide would, however, create a critical juncture between terminally ill people and the non-terminally ill. The latter would continue to be the object of state concern, but the former, for the first time in our nation's history, would cease to be so, at least as far as physician-assisted suicide is concerned. Since legalized physician-assisted suicide makes such a critical distinction, literally a life and death difference, to be dependent on the terminal status of people, the proposed legislations must define "terminally ill" with great legal precision. Moreover, this precise legal construct must reflect an equally precise medical one if it is not to be a completely arbitrary distinction.

In fact, however, the proposed legal standards of "terminally ill" have not been formulated with the precision that such a distinction demands. Even worse, as far as the proponents of physician-assisted suicide are concerned, the medical reality that the legal definition should reflect is anything but precise. The result is that the legal attempt to base physician-assisted suicide on accurate medical prognoses is unsuccessful in practice, impossible in theory, foolish at best, and wicked at worst.

II. THE ORIGIN AND USES OF MEDICAL STATISTICS

Medicine is a science because all human beings have the same fundamental anatomy and physiology; in a phrase, because all people are alike. Medicine is an art because in no two human beings is this anatomy and physiology exactly the same; all people are different. The tension between these two opposites necessitates that medicine be an artistic science and a scientific art.

Throughout its struggling and often noble history, the goal of medicine has been to relieve suffering and prolong lives.³ Rare indeed is the disease or treatment whose outcome has been 100% predictable. Doctors gathered data on outcomes of different treatments, therefore, for the purpose of comparison. This was not idle curiosity. The doctors wanted to apply the aggregate

2. Were physician-assisted suicide legalized, it would be a defined part of medical practice and therefore subject for reimbursement under Medicare and Medicaid.

3. Proposals to legalize euthanasia, of course, are contrary to this tradition. They are based on the false claim that relief of suffering can only be accomplished by ending lives.

data to individual cases, not (as in the current proposals) to select patients for death, but rather to choose the treatment most likely to benefit the patient. In recognition of the variability of outcome, doctors developed risk factor analyses. By stratifying the total population of study according to predetermined risk factors, the doctors could identify outcome according to subgroup. In turn, this type of analysis would allow doctors to identify patients for whom the standard therapy was unsatisfactory. These patients, then, would become candidates for other therapies hypothesized to have a better risk to benefit ratio for the subset.

It is important to recognize, then, that the development of outcome statistics and risk factor identification was always to refine the treatment of future cases, never to select a set of patients to be killed by doctors. From time to time, of course, the data were used to identify patients whose prognosis was so poor even with treatment as to lead the doctor to recommend no disease-specific treatment at all.⁴ This was not because the doctor wanted the patient to die; rather, it was the doctor's clinical judgment that the likely burden of treatment exceeded its likely benefit. The doctor did not choose to not treat the disease; instead, the doctor recognized that it could not be treated. In cases where the treatment was unlikely to be beneficial, and even less likely to be burdensome, it was often tried. As would be expected from their mathematical definition, such last-ditch efforts yielded rare successes.

Survival prediction by diagnosis and other risk factors was, of course, not completely accurate. This inaccuracy was not a major problem, however, when the prognosis was used to select a therapy. The physician's clinical duty was not to be a fortune teller, but rather to do the best he or she could given the information at hand, and, as in the classic dictum, to do no harm. The physician's ethical duties were parallel with clinical ones. Ethics govern the intentions of our actions. Parallel with the clinical duty to do good is the physician's ethical duty to intend to do good. Corresponding to the clinical duty to do no harm is the physician's ethical duty to intend no harm. While the nature of the limits of medical therapeutics would often result in doctors failing to achieve clinical goals, there has never been an apodictic cause preventing doctors from achieving their ethical duties to the patient.

4. Withholding of disease-specific treatment never precluded palliative care, of course.

III. MEDICAL STATISTICS AND PHYSICIAN-ASSISTED SUICIDE

The proposal to legalize the physician-assisted suicide of terminally ill patients has introduced a new application to medical survival statistics, an application completely at odds with the purpose for which they were originally developed, and reflecting an ethic completely at odds with the one which underlay their original use. It will be no surprise, then, that the tool is ill-fitted for this ill-meaning task.

We must ask, what will be the standard of accuracy of survival data when applied to the dubious task of defining patients as potential candidates for euthanasia? How good need our ability to prognosticate be? In clinical practice, a modest margin of error, although not desirable, is still acceptable since it does not preclude our choosing therapies likely to yield the greatest good for the individual at hand. When medical prognoses are used to select candidates for physician-assisted suicide, however, the standard of accuracy must be quite higher. Since the prognosis will be used by the state to assign individuals to different categories of state interest in preservation of life, the accuracy of the prognosis must be very good indeed. How good is very good? Clearly, being wrong half the time is not good enough. Being wrong even 10% of the time is a standard that the law would not accept in criminal trials, and the standard in capital cases must be at least an order of magnitude higher than in other criminal cases.⁵ There is nothing inherent in the criminal law that necessitates that it fall short of this daunting standard; in theory it is achievable. Moreover, despite the stringently high standard of accuracy the law demands in capital cases, these convictions are subject to automatic review. Such are the lengths to which the law goes, and rightly so, to prevent the taking of an innocent life. Surely if the state intends to acquiesce in the taking of life, as is proposed in the legalization of physician-assisted suicide, it must demand at least this same high degree of accuracy to protect the lives of those sick people whom it still deigns to include among the objects of its interest.

That the standard of accuracy of prognosis must be this high for a law proposing to legalize physician-assisted suicide may be demonstrated by a simple *a fortiori* argument. Suppose that a law were proposed that would deny voting rights to terminally ill people. The theory behind such a law would be that the termi-

5. It is immeasurable, of course, how accurate the criminal justice system is in practice. But the standard that criminal law sets as its goal is for all convictions to be correct verdicts. That goal is so important, in fact, that the law allows there to be some false acquittals in order to achieve this high rate of true convictions.

nally ill are not going to be alive during the term of the elected official, and therefore should have no say as to who that official will be. Offended and outraged patients would bring suit against the government that passed such laws, arguing, among other things, that the great inaccuracy of prediction makes the law arbitrary and unconstitutional. It is hard to imagine courts which have already discarded limitations on the franchise based on literacy, language, and poll tax would not be sympathetic to such a claim, even if they accepted the theory underlying the law. If the courts should demand a very high standard of prognostic accuracy for deprivation of the right to vote, *a fortiori* they and we must demand an even higher standard to justify deprivation of the state's interest in preservation of life.

The most widely available and reproducible type of survival statistic in medicine, median survival from the time of diagnosis, is also the least useful for the purposes of physician-assisted suicide proponents. Median survival is the length of time it takes for half a population to die. By definition, half the population lives longer than its median survival. This datum is useful for those wanting to improve the survival of the whole group since it reflects the performance of the whole group. To adopt a median survival of six months as the standard for application of physician-assisted suicide would, however, eliminate even the modicum of concern that proponents of euthanasia express for the lives of sick patients. A median survival time of six months may be seen, for example, with a disease that is curable 50% of the time.

The mean survival time, again measured from the day of diagnosis, is no more useful than median survival for the dubious purposes of physician-assisted suicide proponents. Mean survival is simply the average survival. Distribution curves of survival are, however, virtually never bell-shaped. The typical heavy clustering of deaths early in the observed period throws the mean survival time well beyond the median survival time. In other words, a few long-term survivors greatly prolong the mean survival. But if less than half of the group are long-term survivors, the median survival may remain quite brief. It is important to keep in mind that a good number of long-term survivors and even cured patients live well beyond the mean survival time. By their very definition, there are *always* patients who live longer than both median and mean survival times.

Rather than median or mean survival time, the kind of estimate needed for this novel denial of civil rights⁶ is *maximum sur-*

6. That is, a class-based abandonment of state interest in maintaining life.

vival time. Since this kind of statistic has little use in clinical medicine, there is much less published research concerning these statistics. The research available is well done, however, and worthy of close consideration.

IV. PRACTICAL LIMITATIONS IN DEVELOPING AND APPLYING MEDICAL STATISTICS

Lynn and some other authors have reviewed the problems in applying aggregate statistics to individuals and identified five elements central to helping physicians determine whether a model developed to predict survival is applicable to a particular patient.⁷ The first question that the clinician must ask is how similar his or her patient is to the patients used to develop the model. In practice, there are almost always major differences between the two. If nothing else, the passage of time since the study was conducted makes a major difference. The steady improvement in supportive care, even if there has been no improvement in disease-specific treatment, makes current patients imperfectly comparable to those treated in the past. Many published models are based on outcomes in academic medical settings, yet the majority of individuals treated in this country receive their care in community-based medical facilities. If the model is based on a prospectively randomized clinical trial, attention must be paid to the entry inclusion and exclusion criteria of that study, since the individual patient may not have qualified for entry into that study and hence would be a member of an entirely different clinical population.

Often overlooked is the fact that clinical staging itself has changed with progress in diagnostic techniques. More accurate staging improves the outcome in all stages of illness even if the treatment effects do not change. For example, improved diagnostic imaging techniques allow us to detect tiny metastases of cancer that would have gone undetected with older technology. The patient in whom such metastases are discovered with the modern technology is diagnosed as having a higher stage disease than the patient would have been if he or she had been evaluated with the older technology. Obviously, patients who just barely qualify as having advanced stage disease have a better prognosis than those in whom metastases are large and multiple. Including these patients with previously undetectable metastases in the worst prognostic group dilutes that group's poor prognosis with patients who will likely do better than the previous average.

7. Joanne Lynn et al., *Accurate Prognostications of Death—Opportunities and Challenges for Clinicians*, WEST J. MED. 250-57 (1995).

The overall prognosis for that stage of the illness is thus improved. Similarly, removing the patients with previously undetectable metastases from the better prognosis group improves the average prognosis of that group, since those removed patients would have had a poorer than average outcome. Thus the mere shifting of patients from one stage to another due to more accurate clinical staging improves the prognosis of all groups independent of any improvement in disease treatment.⁸

Second, we must examine the pertinence of the study's end point to the patient at hand. If application of physician-assisted suicide depends on the likelihood of survival for six months, then data from studies with end points at two months or twelve months are clearly inapplicable. Another problem is that many patients used in studies are lost to follow-up. As such, there is a serious risk of unreliability in the study, no matter how the data concerning the cases is handled. If, for statistical purposes, a patient is assumed to have died at the last contact date, an inaccurately low mean survival time is likely to result. If the patients lost to follow-up are simply censored from the data analysis, the resultant error is not eliminated, but its vector is unknowable. Obviously, if patients are lost to follow-up because they die, that has a tremendously different statistical implication from their being lost to follow-up because their health improves and they relocate.

The third question concerning the applicability of a published survival study considers whether the predictor variables are well chosen, of appropriate number, and reliably measured. For example, some survival studies are based on "diagnosis-related group" data generated for billing purposes during a hospitalization. Not only does such a study introduce a serious question concerning accuracy of diagnosis, it assumes as a precondition for study entry that the patient is sick enough to be hospitalized. Patients well enough to be living at home may have a vastly different prognosis. Moreover, physiologic measurements, such as nutritional status and performance status, may have a more important impact on survival than does simple diagnosis or even stage of illness.

If a study tests too many variables, the result might be "overfitting." Such studies become more accurate in predicting the outcome of fewer individuals. This is because the more vari-

8. This has been called the Okie effect, or Will Rogers effect, based on the quip by Will Rogers that when the Okies moved to California, that raised the average IQ in both states.

ables measured in a study, the more patients are needed to make that study reliable.⁹

When studies are retrospective, information is often missing from the original documents. Missing data are often assumed to be normal for study purposes. Such an assumption is potentially misleading, however, since many patients would have had abnormal data had they been measured. Moreover, the presence or absence of certain data from the medical record is probably not a random event. It may be that patients were either too sick for the datum to matter—hence it was not measured—or too well for the datum to be a concern. In either case, the data are not missing for reasons that may be expected to be equally distributed across the whole study population.

In some studies, a predictor variable is used that is not present in the individual patient. For various clinical reasons, it may be impossible or unethical to measure that variable in the patient. Depending on the weight given to that variable in the published study, the data may be radically skewed in its applicability to the individual.

The fourth question we must ask about survival models is how the models' accuracy was quantified. This question has two aspects. The first question concerns calibration of the model. Calibration is the measurement of how well a model predicts survival over the entire range of the model. In a sense, calibration refers to the average accuracy of the model. Only models of high calibration are likely to be useful for predicting survival. The second aspect to be considered in assessing a predictive model is its discrimination. It is possible that the model is quite accurate at predicting survival at certain points in time but not others. For example, there may be a high correlation between predicted and actual survival at one week, but far less correlation at six months. If survival curves are used to predict survival at six months, they must discriminate very well at that time period, no matter what their overall calibration is.

Finally, and most importantly, we must ask of a survival model whether it has been validated. Developing a mathematical formula from a given cohort of patients and examining how that formula discriminates within that cohort concerning their survival is quite different from taking that same mathematical formula and applying it to a new population. The ability of a model to predict survival in this second population is the key test of a model's predictive value. Without such a test, a model is

9. Frank E. Harrell, Jr. et al., *Regression Modelling Strategies for Improved Prognostic Prediction*, 3 *STATISTICS IN MEDICINE* 143-52 (1984).

little more than an untested theory with respect to its predictive use.

There are certainly numerous published studies concerning survival of cohorts of patients with different clinical problems. Far fewer studies develop a model to predict survival of subjects within the original population. Rarer still are studies that then apply such a model prospectively to a new population, yet only this last type of study may be considered as having even potential validity for the purposes that physician-assisted suicide supporters propose.

Finally, a word must be said concerning what may be the most important persisting limitation on a predictive model, even one that has met the daunting challenges outlined above. That is, most of these models do not consider variations in treatment. This is not because treatment has little effect on survival outcome, rather, it is because the predictions of survival are made before the treatment is rendered. Survival models necessarily assume "typical treatment" will be applied to the population. It is difficult to see how treatment effects can routinely be used in predictive survival models, since learning of one's prognosis might influence a patient's decision to accept treatment, one way or the other. It is even more difficult to believe that the treatment chosen is not, for better or worse, a significant prognostic factor.

V. FEEDBACK IMPACT OF PHYSICIAN-ASSISTED SUICIDE ON VALIDITY OF PROGNOSTICATION

If physician-assisted suicide were legalized, the survival data upon which treatment decisions are made will become further skewed and less reliable due to a pernicious feedback phenomenon. As will be shown below, the best survival predictions still err in about 15% of patients. The individuals to whom the statistics erroneously apply are impossible to predict. Presumably some of the patients whom the doctors erroneously declare to have less than six months to live will choose physician-assisted suicide (or have it chosen for them by court-sanctioned substituted judgment). Thus, if physician-assisted suicide were legalized, the average survival of patients predicted to live less than six months would be shortened by euthanasia itself. Much of the physician-assisted suicide legislation stipulates that the cause of death to be listed on the death certificate shall be the original diagnosis rather than suicide or homicide. Thus, a second iteration of the predictive model even if it were repeated on the original population would find an increase in discrimination at six months when compared to the original calculation. This appar-

ent increase in the predictive value of the model is ironically due to the fact that more patients truly destined to live beyond six months had their lives shortened by euthanasia. This is the very opposite of the goal of prognostication in this setting. Thus, the legalization of physician-assisted suicide, *eo ipso*, would reduce the already dubious validity of the very reed upon which it leans.

VI. DEPRESSION, SUICIDE, PHYSICIAN-ASSISTED SUICIDE, AND PROGNOSIS

The most likely setting in which the legalization of physician-assisted suicide would adversely affect prognosis and thereby distort prognostic models is the case of depression. The terrible prevalence of depression and suicide bears emphasis: the prevalence of major depression is between 5 and 20% in this country.¹⁰ Major depression is a serious risk factor for death by suicide. Fifteen percent of patients with recurrent depression die in that tragic fashion.¹¹ It should come as no surprise that patients with serious illness are at increased risk of major depression. Almost one fifth of patients hospitalized because of coronary artery disease are clinically depressed. Among cancer patients the prevalence is 20 to 42%. Depression is also frequently seen as a complication of central nervous system diseases,¹² such as multiple sclerosis, stroke, Alzheimer's disease, and Parkinson's disease.¹³

Unfortunately, although depression is more common among the serious ill than in the population at large, the diagnosis of depression is often missed in the setting of advanced illness. All too often physicians confuse depression for grief, or believe that depression is "normal" in the seriously ill. This is tragic, because the seriously ill patient with depression benefits as much from drug therapy as does a somatically well patient.

A depressed patient usually does not meet the legal criterion of mental incompetence. Depression is a mood disorder, not a thought disorder. Thus, a depressed patient, even a suicidal one, may be held in a psychiatric treatment facility involuntarily for only a few days. In the long run, a depressed patient's reception of treatment requires informed consent. A suicidal patient who

10. Darrel A. Regier et al., *One-Month Prevalence of Mental Disorders in The United States*, ARCH. GEN. PSYCHIATRY 477-86 (1988).

11. S.B. Guze & E. Robins, *Suicide and Primary Affective Disorders*, 117 BRIT. J. PSYCHIATRY 437-438 (1970).

12. There is little wonder that so many patients with chronic neurologic disorders may be found on the list of those who have died "in the presence of" Jack Kevorkian.

13. S.E. Hyman et al, *Mood and Anxiety Disorders*, in SCIENTIFIC AMERICAN MEDICINE § 13 (D.C. Dale and D.D.Federman eds., 1995).

refuses treatment for depression, or who is never offered such treatment, is at high risk of completing suicide. Those depressed patients who sincerely profess the intention to kill themselves and who do not receive treatment have a significant risk of dying, and some clinicians might reasonably predict many such patients as being unlikely to survive as long as six months.

Ironically, the legalization of physician-assisted suicide would place physicians and patients in a terrible dilemma. The law requires the doctor to obtain a patient's informed consent for treatment. Such consent is not valid unless the physician has informed the patient about the potential risks, benefits, and alternatives to the proposed course of therapy. If the patient expresses willingness to accept therapy of his depression, *ipso facto* his or her prognosis improves, and the doctor therefore need not bring up the subject of physician assistance in the suicide. On the other hand, if the patient expresses initial refusal or even reluctance to accept the medical therapy of depression, his or her prognosis considerably worsens, and in some cases worsens sufficiently to lead the doctor to conclude the patient is unlikely to survive six months. Such a conclusion triggers the doctor's duty to explain the alternative "treatment" for which the patient then qualifies. Rather than trying to prevent the suicide, in the most difficult cases the physician has a duty to inform the patient that he or she may legally seek a physician's assistance in performing it! Of course this offer of assistance in suicide, coming from an authority figure such as a physician, will only increase the likelihood of completed suicide. Thus the very people at greatest risk of this fatal complication of depression are the ones most likely to die as a result of legalized physician-assisted suicide. Such are its tender mercies!

Above all others, hopelessness is that aspect of depression most highly correlated with suicide.¹⁴ Among hospitalized medically ill patients, a loss of rapport between hospital staff and patient is the most significant sign of impending suicide.¹⁵ The legalization of physician-assisted suicide would pervert the therapeutic liaison between depressed patient and physician. Patients most at risk of suicide because of hopelessness would have their desperation worsened by the physician's grim prognosis. Patients most in need of a physician to counsel hope and

14. Aaron T. Beck et al., *Hopelessness and Suicidal Behavior*, 234 JAMA 1146-49 (1975).

15. Peter Reich & M.J. Kelly, *Suicide Attempts by Hospitalized Medical and Surgical Patients*, NEW ENG. J. MED. 298-301 (1976).

therapy would feel and be betrayed by a doctor offering help in killing them.

Thus, legalization of physician-assisted suicide would create a pernicious positive feedback loop; that is, the patients with the worst prognoses would be most likely to have their prognoses worsened. The increased case fatality rate among patients with suicidal depression would lead, on further iteration of statistical analysis, to a progressively worse prognosis for the group as a whole. This, in turn, would justify new rounds of grim prognoses and grim reapers.

The promise by physician-assisted suicide proponents that depressed patients will be excluded from their dubious anodyne gives little comfort. Certainly, those court rulings that find physician-assisted suicide to be a constitutionally protected right, whether due to a Fourteenth Amendment "liberty" interest¹⁶ or Equal Protection Clause¹⁷, seem to allow little room for protection of this population. The disabled, even the mentally disabled, have the same recourse to constitutional rights as do other citizens. Again, the suicidal depressed patient is mentally competent under the law, and there are no legitimate grounds by which the patient's constitutional rights may be diminished.

Even if physician-assisted suicide is enacted through the legislative process, explicitly excluding depressed persons, there is little reason to think these paper barriers will long endure. Certainly, for reasons cited above, exclusion of depressed patients from physician-assisted suicide is unlikely to withstand challenge on constitutional grounds. Equally as important, the widespread failure of doctors to recognize and treat depression in the severely ill would lead to a *de facto* inclusion of numerous depressed patients among those whose lives end at their doctors' hands. Indeed, clinical experience suggests that a *majority* of those people dying of physician-assisted suicide would be depressed. The reason is that most terminally ill patients expressing a serious and pervasive desire to die are in fact clinically depressed.¹⁸ Moreover, the precedent established in a foreign jurisdiction, where a doctor could subject a healthy

16. *Compassion in Dying v. Washington*, 79 F.3d 790, 798 (9th Cir. 1996), *en banc*, cert. granted, *Washington v. Glucksberg*, 65 U.S.L.W. 3254 (U.S. Oct. 1, 1996) (No. 96-110).

17. *Quill v. Vacco*, 80 F.3d 716, 731 (2d Cir. 1996), cert. granted, *Vacco v. Quill*, 65 U.S.L.W. 3254 (U.S. Oct. 1, 1996) (No. 95-1858).

18. Harvey Max Chochinov et al., *Desire for Death in the Terminally Ill*, 152 AM. J. PSYCHIATRY 1185-91 (1995).

depressed patient to physician-assisted suicide with impunity, is frightening, to say the least.¹⁹

VII. EMPIRICAL LIMITS OF PROGNOSTICATION

In science, only the voice of data is authoritative. The published studies concerning reliability of life expectancy prediction do not support the assumption of physician-assisted suicide proponents that such predictions can be made with requisite reliability. A number of studies employing a variety of techniques all point to this same conclusion.

Parkes presented one of the earliest studies apposite to our question.²⁰ His study population included patients admitted to the world-renowned St. Christopher's Hospice in London. Referring physicians were asked to predict the life expectancy, in weeks, of admitted patients. The same question was asked of experienced medical and nursing staff of the hospice. In nearly three-fourths of the referred cases, the referring doctor was unwilling to commit to a precise prediction. In the remaining cases, presumably thought by the doctors to be easier to predict, the patients lived longer than predicted in 26% of the cases. In 7% of the cases predicted by the referring physician, the patient lived more than twice as long as the doctor had predicted. The predictions by the hospice admitting physicians were not significantly better or worse than the predictions made by general practitioners, physicians at other hospitals, or senior nursing staff.

A similar study was conducted in the United States by Forster and Lynn.²¹ In the part of their study pertinent to our question, the life expectancy of 108 applicants to an in-patient hospice was predicted by five different people: a consulting university oncologist, a board-certified general internist, a hospice social worker, a board-certified community oncologist, and a registered nurse. A prediction was scored as "seriously pessimistic" if the prognosis was for less than three months, but actual survival was twice as long. Five percent of the prognoses met this criterion of seriously pessimistic. If the predictions of the community oncologist, whose prognoses were "seriously optimistic"²² 36% of the time,

19. Alan D. Ogilvie & S.G. Potts, *Assisted Suicide for Depression: The Slippery Slope in Action*, 309 BRIT. MED. J. 492-93 (1994).

20. C. Murray Parkes, *Accuracy of Predictions of Survival in Later Stages of Cancer*, 2 BRIT. MED. J. 29-31 (1972).

21. Lorna Earl Forster & J. Lynn, *Predicting Life Span for Applicants to Inpatient Hospice*, 148 ARCH. INT. MED. 2540-43 (1988).

22. A seriously optimistic prognosis was defined as one in which the prediction was survival greater than six months, but the patient lived fewer than three months.

were excluded from the study the percentage of errors deemed seriously pessimistic would have been even higher.

Predictions using a cut-off of one month survival seem to be no better than the ones based on three or six months. In a prospective study conducted at the Edmonton General Hospital in Canada, Bruera and some other authors predicted the survival of 61 consecutive patients admitted to the Palliative Care Unit for terminal care.²³ Life expectancy of either less than or greater than four weeks was made by two different physicians, both expert in the management of patients with advanced cancer. Fourteen of the patients were not evaluable. Among the remaining forty-seven patients, one doctor predicted a life expectancy less than four weeks in thirty-three of them. The doctor erred in this prediction 60% of the time, however. The other doctor predicted survival less than four weeks in twenty-five patients. That doctor's error rate was 64%.

It might be thought that a predictive model based on objectively measurable predictors would be more accurate than the gestalt-based prediction of even skilled personnel. In fact, however, an objectively based model fared no better, and arguably was worse than the predictions of skilled observers in this setting. Using the same data base as in the above-cited study, Forster and Lynn developed a logistic regression model to predict death within three or six months.²⁴ It is important to note that this model was then applied to the same patient population, not to a new one. Thus, the model is untested for any population other than these one hundred and eight patients, and the accuracy of these results is therefore the maximum this model can hope to attain. Fourteen objectively measured risk factors were considered in the model. Among the patients whom the model predicted to live less than three months, 10% lived longer. Among those whom the model predicted to live less than six months, 5% lived longer.

To make matters even less reliable, prognostic factors identified as being well-correlated with survival in one study do not seem to be so in others. For example, Rosenthal along with some other individuals assessed nineteen parameters potentially associated with survival in hospice patients.²⁵ Only four of these risk

23. Eduardo Bruera et al., *Estimate of Survival of Patients Admitted to a Palliative Care Unit: A Prospective Study*, 7 J. OF PAIN AND SYMPTOM MGMT. 82-86 (1992).

24. Loran Earl Forster & J. Lynn, *The Use of Physiologic Measures and Demographic Variables to Predict Longevity Among Inpatient Hospice Applicants*, AM. J. HOSPICE CARE, March/April 1989, at 31-34.

25. M.A. Rosenthal et al., *Prediction of Life-Expectancy in Hospice Patients: Identification of Novel Prognostic Factors*, 7 PALLIATIVE MED. 199-204 (1994).

factors proved to be associated with survival. Three of these factors had not been identified in prior studies. More importantly, the study found no association between their patients' survival and four putative predictors identified in these other studies. Thus, the cross-study reliability of many risk factors for survival of terminally ill patients is not well established.

The largest study concerning reliability of prognoses is the very recent one presented by Christakis and Escarce in which they studied the actual survival time of 6451 patients who had enrolled in the Hospice Medicare program.²⁶ In order for a Medicare beneficiary to be eligible for this program, both the patient's referring physician and the hospice medical director have to certify that the patient is "terminally ill," i.e. has a life expectancy of six months or less. The authors found that 15% of the patients were still alive after the time predicted by their doctors. In fact, 8% of the patients were still alive at the end of a year.²⁷ This inaccuracy of prognosis was not evenly distributed across the whole study population. The referring physician and medical director were particularly likely to make "pessimistic errors" with demented patients. Over a third of them lived beyond the predicted six months.

Adding a third doctor to the prognosticating team does not dramatically improve the accuracy, certainly not to the level of accuracy that legalized physician-assisted suicide would require. Allard and other authors presented data concerning 1081 terminally ill cancer patients admitted to a palliative care center in Quebec.²⁸ As the authors noted, priority for admission into the center was given to terminally ill cancer patients for whom life expectancy was considered to be shorter than two months. The estimate of life expectancy was made by a three-member medical panel, and was based on "an extensive review of all available data on cancer staging and progression, and on an extensive clinical assessment made by experienced palliative care nurses." Despite this stringency of entrance criteria, 9% of the patients exceeded the survival time predicted by this experienced medical team.

It will be noted that there is significant variability in the accuracy of physicians' prognoses as seen in these studies. At best, when the error rate approaches single digits, the accuracy rate is

26. Nicholas A. Christakis & J.J. Escarce, *Survival of Medicare Patients After Enrollment in Hospice Programs*, 335 *NEW ENG. J. MED.* 172-78 (1996).

27. *Id.* Christakis and Escarce do not report what percentage of the doctors had died during this time. *Id.*

28. P. Allard et al., *Factors Associated With Length of Survival Among 1081 Terminally Ill Cancer Patients*, 11 *J. PALLIATIVE CARE* 20-24 (1995).

adequate for legitimate medical purposes, but even then it comes nowhere close to matching the high standard of accuracy that physician-assisted suicide would require. To predicate physician-assisted suicide on physicians' ability to predict life expectancy with very high degrees of accuracy is to build a house on sand — its foundation gives no support.

VIII. THEORETICAL LIMITS OF PROGNOSTICATION

The research cited above demonstrates that empirical studies have not shown an accuracy sufficient for the needs of legalized physician-assisted suicide. The question arises: Could other studies, using other methods, achieve a level of accuracy substantially greater than these? The answer is no.

Human survival must be either stochastic or determinative or a mixture of the two. A stochastic function is non-determinative, although the probability of an event is not necessarily equally distributed across time. "Stochastic" is simply another way of saying "things just happen." Most medical experimentation involving survival time assumes that the percentage of the population surviving at any given time reflects the operation of underlying stochastic processes. By definition, stochastic events are non-determinative. Obviously, individual non-determinative events cannot be predicted with a high degree of accuracy, although aggregates of such events may be described. If survival of terminally ill patients is stochastic, then there is a theoretical limit of prognostic accuracy that cannot be breached, no matter how clever the researchers and their predictive models.

Even if human survival is completely determinative, it is quite likely that the dynamics of chaos theory apply to it. "Chaos," as used here, does not mean the tohubohu that preceded the creation described in Genesis. Rather, it is a fairly new branch of mathematics and mechanics that deals with determinative systems that exhibit apparently random or unpredictable behavior. A common element in these systems is a very high degree of sensitivity to initial conditions and to the way in which they are set in motion. Very small changes in these initial conditions can lead to enormous changes in the outcome. For example, whether one is stopped by a given red traffic light can have a huge impact on the events one will experience later in the day, or even for the rest of one's life. This exquisite sensitivity to initial conditions has been called the "butterfly effect," after meteorologist Edward Lorenz's euphonious speculation that the flap of a butterfly's wings in Brazil might set off a tornado in Texas.

Human survival would seem to be a reasonable application of chaos theory. We assume that our health tomorrow will be a con-

sequence of the state of our bodies and the forces applied to them today. For cancer patients, it is reasonable to assume that the current location, number, and growth rate of their tumors, as well as the patient's nutrition, immune function, and comorbidities will determine their overall health tomorrow, just as tomorrow's status of these variables will determine how they align the next day. Perhaps we should use chaos theory rather than stochastic models to analyze survival time of terminally ill people, and perhaps such analysis would yield more accurate predictions in individual cases.

In fact, early forays into medical prognostication, using chaos theory, have already been made. Determinative chaotic models can be created that fit the data derived from cancer survival studies and contagious disease epidemic data.²⁹ Such chaotic models may well yield new insights into the implications of negative and positive clinical trials, but they contain assumptions that make them inapplicable to individual prognostication. For example, a very large number of independent variables must be assumed in these models, and each of them must be measured nearly simultaneously with a near-perfect degree of accuracy. Significantly, the models do not assume any probability of impact of the measurement *per se* on the function measured nor on other functions, an omission that is contrary to all clinical experience. Not only would all these measurements have to be made on the patient, but the current and future status of all who might encounter the patient, either to succor or inadvertently infect him or her, must be considered in the chaotic models. Chaos theory, obviously, may be useful in refining understanding of aggregate behavior, but cannot be applied to individual patients to predict survival time.

Thus, whether survival be stochastic or chaotic, even in theory we cannot predict an individual's survival with accuracy adequate for the needs of physician-assisted suicide.

IX. CONCLUSION

Proposals that limit physician-assisted suicide to terminally ill patients are based on the false assumption that such patients can be identified with a fair degree of precision. Highly accurate predictive models of survival are difficult to create, harder to apply, scanty in number, flawed in practice, and impossible in

29. M.C. Mackey & J.G. Milton, *A Deterministic Approach to Survival Statistics*, 28 *J. MATHEMATICAL BIOLOGY* 33-48 (1990); G. Sugihara & R.M. May, *Nonlinear Forecasting As a Way of Distinguishing Chaos From Measurement Error in Time Series*, 344 *NATURE* 734-41 (1990).

theory. Not only is the proposed law thus predicated on a chimaera, the attempted application of the law would increase the error upon which it is based. If physician-assisted suicide were legalized, an increasing number of people who are not truly terminally ill (absent such laws) would become so by the law's very enactment. The infamous slippery slope is thus mathematically demonstrable in this microcosm, just as it is sociologically predictable in the macrocosm of public policy.

When adverse consequences of public policy are inadvertent, the authors of the policy may be criticized for lack of foresight or wisdom. When the adverse consequences are unavoidable and predictable, and all the more so when they are predicted and demonstrably inevitable, then the authors of such policy merit a far greater criticism. How more contemptible yet must be the proposed legalization of physician-assisted suicide, whose excesses and abuses are not simply theoretical. They are already tragically manifest, both in the Netherlands, and in Michigan in the dubious career of the nation's most notorious serial mercy killer. Legalization of physician-assisted suicide would result not only in the state-sanctioned killing of terminally ill people, it would also lead to the killing of increasing numbers of non-terminally ill people—the misdiagnosed, the misprognosed, the misfashioned, and the misunderstood. Only a state indifferent to such an outcome would allow such legalization. Such a state, no less than our matriarch in *Paradise Lost*, would truly be “defac't, deflourd, and now to Death devote.”