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What Are Survival Curves? A survival curve is a statistical picture of the survival experience of some group of patients in the form of a graph showing the precentage surviving versus time. A survival curve cannot be summed up with a single number such as the median survival or the five year survival, despite all too frequent attempts to do so.

Why are They Important? The best known way to estimate your prognosis is to compare it to the experience of other patients in a similar situation treated similarly, as represented by a survival curve. You will often find survival curves inhabiting technical papers in the medical literature, and some understanding of these curves is essential to understanding the technical literature. But survival curves, like other things statistical, have subtleties and important limitations, and are very easily misinterpreted, often in the direction of underestimating hope. Understanding survival curves will help clarify your thinking about treatment choices as well as about prognosis. Here is an idealized example: A Survival Curve Shows the Fraction of People in the Group Surviving Over Time. The vertical (or Y) axis, gives the proportion of people surviving. The value is a fraction which runs from 1 at the top to zero at the bottom, representing 100% survival to zero percent survival at the bottom.

Often the actual percentage is used rather than a proportion. The horizontal (or X) axis, gives the time after the start of the observation or experimentI have seen the time given in days, in weeks, in months, and in years on different survival curves, so it’s very important to pay attention to what the unit of time is! It’s important to understand that even if they started observing or treating different patients at different times, the curve represents the experience of each patient from the time that observation or treatment started for that patient. As an example, if two patients start in a clinical trial four months apart and each survives a year after they start in the trial, in the survival curve they are both counted as surviving one year. Any point on the curve gives the proportion or percentage surviving at a particular time after the start of observation. For example, the blue dot on the example curve shows that at one year, about 75% of patients were alive. A survival curve always starts out with 100% survival at time zero, the beginning.

From there it can descend or stay level, but of course it can never increase. Real-World Survival Curves are Usually “ Staircases” Most real life survival curves are not portrayed as smooth curves as in this example. Instead, they are usually shown as staircase curves with a “ step” down each time there is a death.

This is because a real-world survival curve represents the actual experience of a particular group of people. At the moment of each death, the proportion of survivors decreases and the proportion of survivors does not change at any other time. Thus the curve steps down at each death and is flat in between deaths which leads to the classic staircase appearance. For the most of the rest of this article and my other articles on survival curves, I’ll show the more typical staircase curves. While a staircase does represent the actual experience of the group whose survival is portrayed in the curve, it does not mean that the risk of an individual patient occurs in discrete steps at specific times as shown in these curves. If you are looking at a survival curve that applies to you, don’t read too much into the exact position of the steps or the fact that the curve is flat between steps! Actually, the experience of a particular group as represented by a staircase curve can be considered an estimate or sample of what the “ real” survival curve is for all people with the same circumstances. As with other estimates, the accuracy improves as the sample size increases. With staircase curves, as the group of patients is larger, the step down caused by each death is smaller.

If the times of the deaths are plotted accurately, then you can see that as the size of the group increases the staircase will become closer and closer to the ideal of a smooth curve. Two Not So Special Points on a Survival CurveI often see discussions which treat five year survival or the median survival as if they were the whole picture. In fact, each of these is just a single point on the survival curve – just one dot from the whole picture. The basic meaning of five year survival is self explanatory, but often people think that five year survival is the same as cure. For some cancers this may be true. For others it most definitely isn’t. You can’t tell the difference from knowing the five year survival, but you most certainly can looking at a long-term survival curve! The median survival is the time at which the percentage surviving is 50%.

If more than half the patients are cured, there is no such point on the survival curve and the median is undefined (and often described as greater than the longest time on the curve). I like undefined medians! If all you knew about your prognosis was, “ median survival of two years” or “ 5 year survival of 30%” as in this example, you would probably never guess you have a real chance of being alive at 12 years – not unless you had the whole picture, that is to say the whole survival curve – not just one or two points. Not only does this example show a significant level of survival way out at 12 years, but it’s also flat for the last six of those years – no deaths. People fortunate enough to make it out to six or seven years may well be cured. You can’t tell that from the median or 5 year survival or from any other single point.

It’s the shape of the survival curve that tells this story. Now, of course, this is merely a hypothetical example – but some real world survival curves really do look a lot like my example. To see some, have a look at the tour of my changing odds I call, Post Cards from Beyond The Zero. A Few More ExamplesAlthough, in theory, a survival curve can be any shape as long as it never goes up, I typically see two main classes of survival curves. First, curves which flatten to a level plateau, and which suggest that patients are being cured, and second, curves which descend all the way to zero, implying that no one (or almost no one) is cured. Two survival curves which end in a plateau With both of these curves, it looks like people who manage to live six years may be cured. The difference of course is that with Curve A the chances of this are about 75% whereas with B the chances are only about 10%.

But even Curve B offers a real hope of a cure. Two curves which descend to zero Both of these curves reach zero and imply that no one is cured (or at most a very few) but they are very different. With Curve C although there were no cures some people lived quite a few years. Perhaps people in this situation have a cancer they can live with even if it isn’t curable. Curve D – well it’s a disaster – but even so, it doesn’t mean there is literally no hope – see “ flying under the radar” below. Even curves which reach zero or which get very close to it may differ in their shape.

Many curves show a decreasing risk of death over time (If the risk decreases to zero you get a plateau!). Some curves appear to have a roughly constant risk of death over time. A constant risk of death leads to an curve which represents exponential decay like the decay of a radioactive element. In a perfect mathematical world, an exponential decay curve doesn't actually reach zero, but with any limited number of people to start out with, such a curve will eventually reach zero. It can be very difficult to detect decreasing risk by eye – but the evidence is that even for advanced cancers with a poor prognosis there is a good chance the survival curve is decreasing risk.

See my article on Conditional Survival for the details! Flying Under the RadarWith a curve that rapidly descends to zero, the temptation is to conclude that there is no chance of a cure or exceptional survival – that the situation is literally hopeless. I believe this to be a dreadful mistake. Although touching the zero seems to exclude the possiblity of living longer, the relatively small sample in survival curves cannot be expected to show the miracles and exceptions. I believe as an article of faith that there is no disease from which someone has not recovered.

Survival curves constructed from a limited sample size cannot cover the real range of possiblity! If you could measure accurately enough, I believe you would find a tiny cohort of extreme long term survivors in every case. These people are flying just above the zero underneath the radar of conventional statistics. Many survival curves I've seen are from relatively modest sized groups — you can certainly get the lay of the land from the experience of 50 or 100 people but this is not enough to exclude even a few percent longer term survivors. With very large groups, the range of possible experience is likely to be more adequately represented, but it is mathematically impossible to exclude the rare exception no matter how large and reliable the sample. Two comparative survival graphsCommonly, several curves from the same clinical trial, or study will be shown on the same graph. The curves may compare results from different treatments as in Graph E. If one curve is continuously “ above” the other, as with these curves, the conclusion is that the treatment associated with the higher curve was more effective for these patients.

There are many ways the two curves could compare. They might be very close to each other indicating there was no difference between the treatments. If a dangerously toxic treatment resulted in more long term survivors than a less dangerous treatment, the curve for the riskier treatment might be lower than the other curve due to early treatment deaths, but end up further off the deck in the end. Typically Graph E would result from a randomized clinical trial (which is designed so that the only statistical difference between the groups is the treatment so that the survival between the treatment groups can be compared). This is the ideal situation – a great deal of caution is needed when comparing survival curves from different studies where patient differences rather than treatment differences might account for the difference.

Graph F shows the survival of four stages of some (hypothetical) cancer. Rather than a clinical trial, this type of comparative curve shows the difference in prognosis from naturally existing factors, in this example, the stage of the tumor. Survival by stage varies greatly by the type of cancer so please don't take this hypothetical example to represent the prognosis for your stage of cancer.

Often it may be unclear whether two curves are really different or whether it is reasonable to assume the difference between them may be just due to chance. There are tests of significance for survival curves, such as the log rank test, and you will often see a " p value" given with comparative survival curves to indicate whether the difference is statistically significant. For more information on statistical significance, read my article " The Significance of Significance.

" Not All Survival Curves Measure Survival!: Other EndpointsWhat Is an Endpoint? An endpoint is something which is measured in a clinical trial or study. Measuring selected endpoints is the goal of a trial. Response rate and survival are examples of endpoints. Many survival curves that you'll encounter in the real world don't actually chart survival. Instead, they chart related endpoints such as the length of time patients remain free of disease. Understand that at a casual glance, these curves look just like simple survival curves! When you find a survival curve in the literature you must read the caption and surrounding text to determine what the curve is actually measuring. Each endpoint is associated with an event which causes the curve to take a step down when that event happens to a patient.

In a plain survival curve, the event which causes the curve to step down is a death. In these variants, the event can be something else, such as the patient suffering a recurrence or relapse. Survival has the advantage that death is an unambiguous event, but all of the other events introduce at least some uncertainty. For instance, determining when and whether there has been a relapse depends on the subjective process of reading scans. Survival is close to most people's ultimate goals while other endpoints may not always translate into ultimate benefit. I will describe the common alternative endpoints in terms of their associated events.

Some Alternative Endpoints: Disease Free Survival (DFS): This is usually used to analyze results of treatment for localized disease which renders the patient apparently disease free, such as surgery or surgery plus adjuvant therapy. In disease free survival, the event is relapse rather than death. People who relapse are still surviving but they are no longer disease-free. Just as in survival curves not all patients die, in DFS curves not all patients relapse and the curve may have a final plateau representing patients who didn't relapse after the study's maximum follow-up.

Because patients survive for at least some time (and possibly a long time) after relapse, the curve for actual survival would look better than the DFS curve. DFS has the advantage that it is not affected by various and diverse treatments that may be tried after relapse. Disease Free Survival is also called Relapse Free Survival.

Progression Free Survival (PFS): PFS is usually used in analyzing results of treatment for advanced disease. The event for PFS is that the disease gets worse or " progresses" meaning the existing tumors grew or new tumors appeared. Logically, Disease Free Survival could be considered a subset of PFS since relapse represents progression of disease. Like DFS, PFS attempts to isolate the effects of the current treatment without being affected by what might be done after that treatment fails. Disease Specific Survival: In this variant, the event is death specifically from the cancer. Deaths from other causes are not " events" and do not cause the curve to decline. Instead, from the time of death forward, a patient who dies from something else is effectively removed from the data. This decreases the number of patients " at risk" from that point forward but does not cause the curve to decline (For more information on how this is done, see my Article on Kaplan-Meier Estimation.

). Disease specific survival has serious problems. Disease Specific Survival ignores deaths which were (or may have been) due to treatment. For a toxic treatment, disease specific survival could be very different from overall survival and it's overall survival that counts in the end.

Subtle late effects of treatment can make it hard to even know how toxic the treatment actually was, a problem which doesn't arise when the endpoint is plain survival. Disease specific survival is also known as Cause Specific Survival. Response Duration: This endpoint is occasionally used to analyze the results of treatment for advanced disease. The event is progression of disease (relapse) but this endpoint also involves selecting a subgroup of the patients. It measures the length of response in those patients who responded (roughly had at least 50% tumor shrinkage). Patients who don't respond aren't included.

Charting only responding patients creates a huge bias, since if the treatment helps people, it probably helps those who respond, and since even if it helps no one, those who are in better health with less disease are can be expected to be more likely to respond. While this type of curve is not appropriate for judging prognosis for those who are starting a treatment, if you have responded to treatment then such curves do apply to you. I also believe that such curves can show probable benefit from treatment if responses appear to be durable beyond what is usual for the type of cancer. For an example, see the duration of response curve for high dose Interleukin-2 therapy of kidney cancer in my article about my own changing prognosis, Postcards from Beyond the Zero. Finally, remember that since patients who relapse survive at least somewhat longer, actual survival of responders would be better than the duration of response.

See my Article on Endpoints in the Research Section for more detailed information on most of these endpoints. Does that Survival Curve Apply to me? To the extent that survival curves are a picture of your prognosis, it’s very important to have the right picture! When you find a survival curve, you need to make sure it’s for the same type and stage of cancer as you have and to the extent possible, that other important prognostic factors (which may be particular to the type of cancer – such as hormone receptor status in breast cancer) are the same. You should be extremely wary of old data – treatments and diagnostic methods may have changed and these things affect survival curves, sometimes dramatically for the better! Survival curves usually are about patients who were all treated a certain way. If that’s not the treatment you got, the curve obviously doesn’t directly apply. Of course, the most exciting possiblity is that you may be able to use survival curves which compare the results of several treatments to decide which treatment is the most promising.