

Cancer Drugs Compared

for safety and effectiveness

By Craig Paardekooper

The dataset used for this study is available for download here [Download](#) [for more info see [Preparation](#)]

The Python code used for this study is here [Python Code](#)

INTRODUCTION

There are 4 different types of therapy for treating cancer -

1. **Chemotherapy**
2. **Targeted Therapy**
3. **Immunotherapy**
4. **Hormone Therapy**

1. Chemotherapy

Chemotherapy drugs target cells that divide quickly, like cancer cells. This kills them or stops them from spreading, which slows the growth of the tumour.

Research has helped to determine the most effective chemo drugs for each situation.

2. Targeted Therapy

Targeted therapy is a precise method of fighting cancer with drugs. The drugs target the molecules involved with the growth or spread of cancer.

Chemotherapy also uses drugs to fight cancer, but targeted therapy is different.

Instead of acting on all rapidly dividing cells – both cancerous and normal – targeted therapies seek out specific molecular targets on the cells. Rather than killing the cells, these drugs interact with them to block their growth and spread.

3. Immunotherapy

Immunotherapy – sometimes called biotherapy (biological therapy) – works with the immune system to treat cancer.

The immune system is the body's defence mechanism. When it detects a threat, it reacts. We call this the immune response.

A strong immune system works to seek and destroy damaged and abnormal cells.

Sometimes, the immune system isn't strong enough on its own. Immunotherapy enhances the actions of the immune system to fight cancer cells.

The immune system consists of organs and cells throughout the body, such as:

- The spleen
- Lymph nodes
- The lymphatic vessels and fluids
- Certain cells in the liver and bone marrow
- White blood cells

Immunotherapy uses concentrated amounts of the body's natural substances – called biologic agents – to push the immune system to work even harder.

Immunotherapy works by further stimulating the immune response.

If the white blood cells aren't strong enough to fight cancer cells on their own, biologic agents can give the system a boost by changing the chemical environment of the cancer.

4. Hormonal Therapy

Hormones are the body's natural chemical messengers. They travel throughout the body to regulate the activity and behaviour of cells and organs.

Hormones play a vital role in functions such as:

- Digestion
- Metabolism
- Sleep
- Reproduction
- Mood

When hormonal activity abnormally increases, cancer can form. Hormone therapy uses drugs to alter abnormal actions of certain hormones.

QUESTIONS

1. Is targeted therapy safer than chemo ? :

It is expected that drugs that only target cancer cells will have less side effects upon healthy cells, and will therefore have a higher safety rating.

2. Is immune Therapy safer than chemo ? :

It is expected that drugs that boost the immune system will have a high safety rating compared to chemo because the immune system is our natural defense against cancer - and therefore will have minimal side effects.

3. Is Hormone Therapy safer than chemo ? :

Hormones are the natural messengers of the body.

EUDRA-VIGILANCE data can be used to compare the **SAFETY** and **EFFECTIVENESS** of

- Targeted therapies
- Immune therapies
- Hormone therapies

compared to chemo.

SAFETY will be measured by -

- incidence of fatality,
- incidence of life-threatening events
- incidence of hospitalisation

EFFECTIVENESS will measure by -

- incidence of complete recovery
- incidence of improvement
- incidence of no recovery

Data for 395 different cancer drugs were utilized. The data was filtered to exclude drugs where the number of cases was less than 100. 152 different cancer drugs remained.

The data for each cancer drug was looked at, regardless of the organ to which the cancer therapy is applied.

RESULTS

The results spreadsheet shows the results for 152 cancer drugs after filtering out drugs with less than 100 case reports. The spreadsheet can be downloaded here -

Results Spreadsheet - [download](#)

The spreadsheet includes data on pain, nausea, fatigue, diarrhea, hair loss, neuropathy, cardiopathy, anemia

You will need to look up each drug to find out if it is Chemo, a targeted therapy, an immune therapy or hormone therapy.

SAFETY IS PARAMOUNT

"**FIRST, do no harm**". Safety is paramount, and should always be considered before effectiveness.

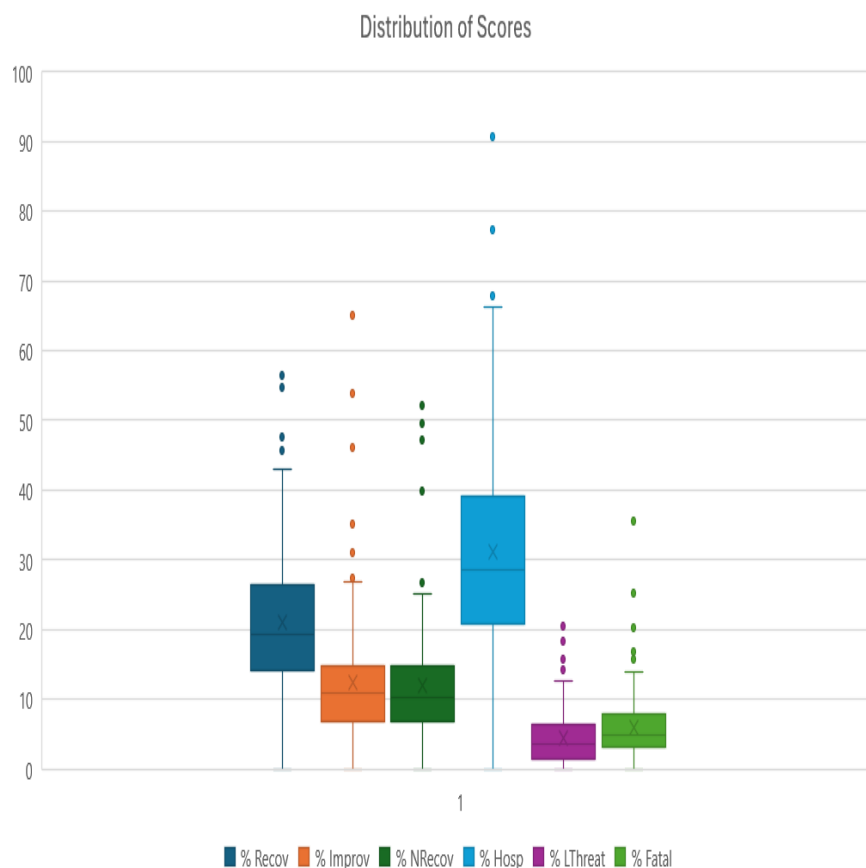
- Is the drug below or above the mean for fatalities, life threatening events or hospitalizations ?
- Better still, what quartile does the drug fall into?
- How many standard deviations is the drug score from the mean ?
- What are the safer alternatives ?

It is all very well saying "If you don't take treatment you will die", but what are the treatment options ? Are some options safer than others ?

DEFINING THE LIMITS OF SAFETY AND EFFECTIVENESS

Based on the spread of the results, we can define the limits of safety and effectiveness

The quartile within which a score falls determines its safety and effectiveness.



DEFINING SAFETY

Safety (quartile ranges)					
Hospitalisation % of Reports		Life Threatening % of Reports		Fatality % of Reports	
count	152.000000	count	152.000000	count	152.000000
mean	31.155263	mean	4.460789	mean	6.026711
std	16.246796	std	4.163557	std	4.787258
min	0.000000	min	0.000000	min	0.000000
25%	20.755000	25%	1.502500	25%	3.110000
50%	28.585000	50%	3.530000	50%	4.910000
75%	39.067500	75%	6.227500	75%	7.900000
max	91.260000	max	20.510000	max	35.480000

SAFE (1st quartile)

- fatality < 3.11
- life threatening < 1.5
- hospitalization < 20

LOW (2nd quartile)

- fatality 3.11 – 4.91
- life threatening 1.5 – 3.53
- hospitalization 20.7 – 28.58

MED (3rd quartile)

- Fatality 4.91 – 7.90
- Life threatening 3.53 – 6.22
- Hospitalization 28.58 – 39.06

HIGH (4th quartile)

- Fatality 7.90 – 13.94
- Life threatening 6.22 – 12.53
- Hospitalization 39.06 – 66.3

EXTREME (OUTLIERS)

- Fatality > 13.94
- Life threatening > 12.53
- Hospitalization > 66.3

DEFINING EFFECTIVENESS

Effectiveness (quartile ranges)					
Completely Recovered		Recovering/Improving		Not Recovered	
count	152.000000	count	152.000000	count	152.000000
mean	21.050592	mean	12.299211	mean	11.900263
std	10.256064	std	9.260022	std	8.329633
min	0.000000	min	0.000000	min	0.000000
25%	14.277500	25%	6.780000	25%	6.947500
50%	19.205000	50%	10.795000	50%	10.235000
75%	26.455000	75%	14.767500	75%	14.712500
max	56.380000	max	65.090000	max	52.160000

POOR

(1st quartile)

- Recovery < 14.27
- Improvement < 6.78
- No recovery > 25

LOW

(2nd quartile)

- Recovery 14.19 – 19.2
- Improvement 6.78 – 10.79
- No recovery 14.71 – 25

MED

(3rd quartile)

- Recovery 19.2 – 26.48
- Improvement 10.79 – 14.76
- No recovery 10.23 – 14.71

GOOD

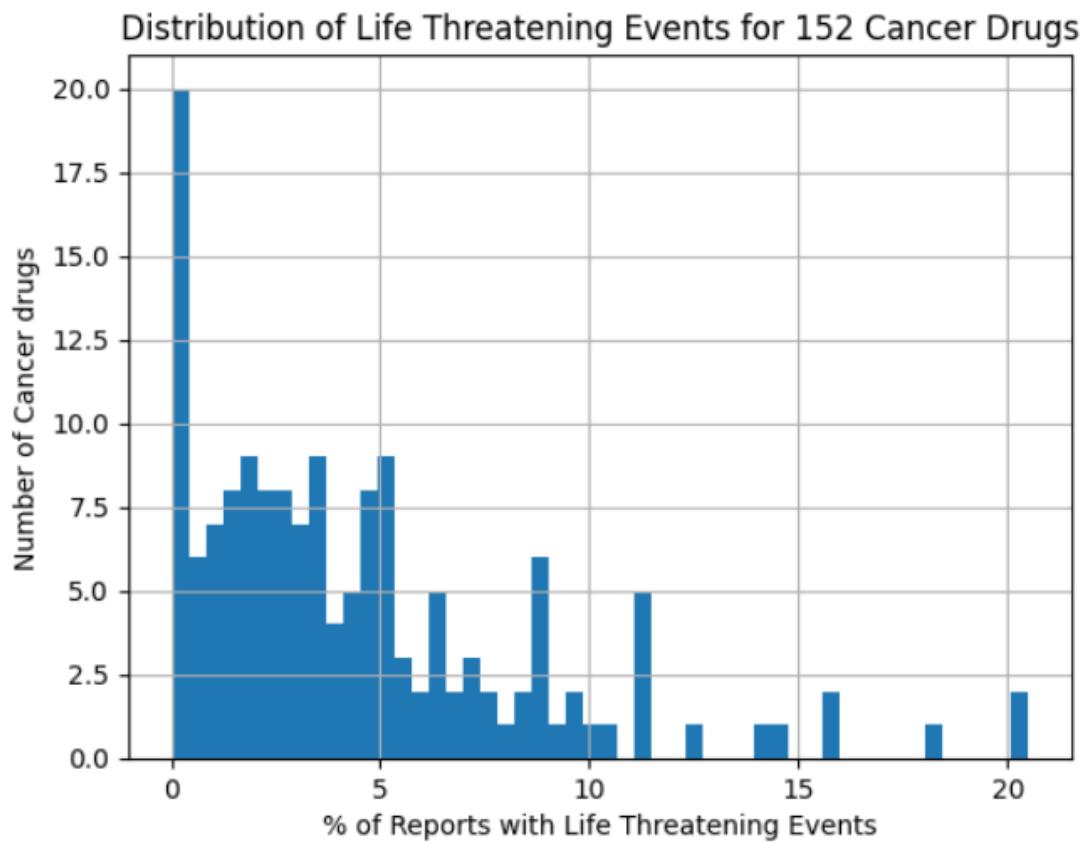
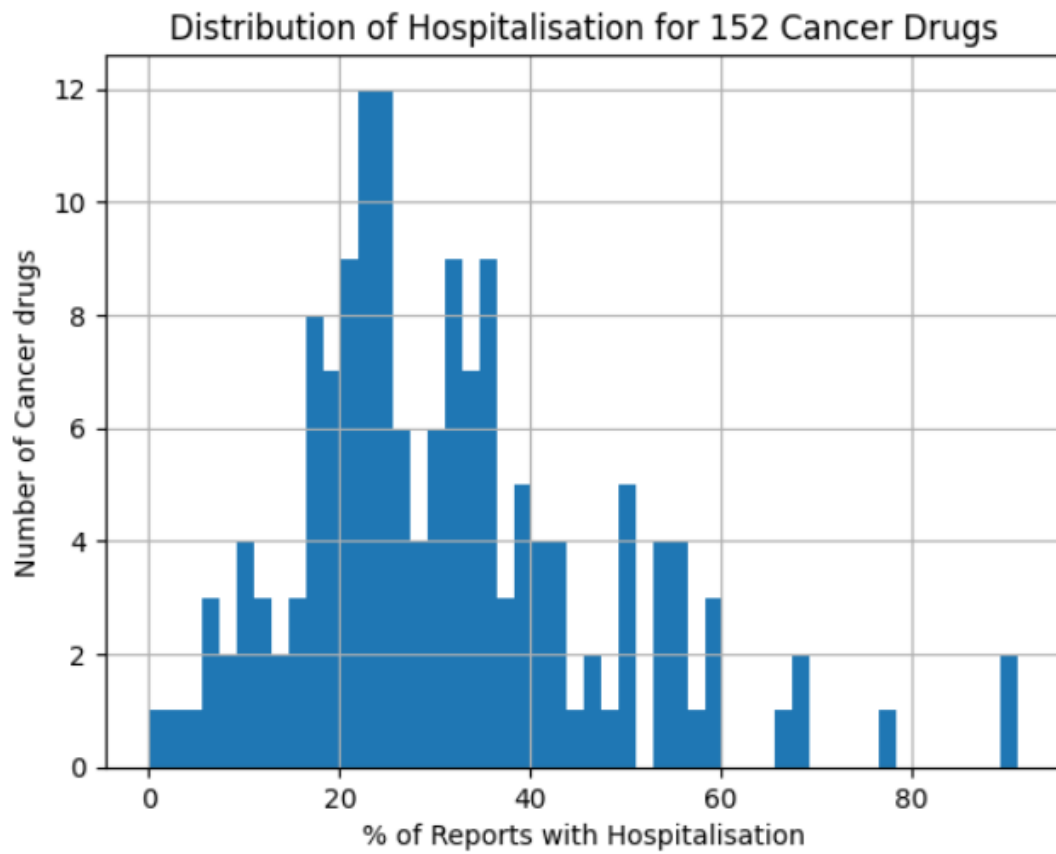
(4th quartile)

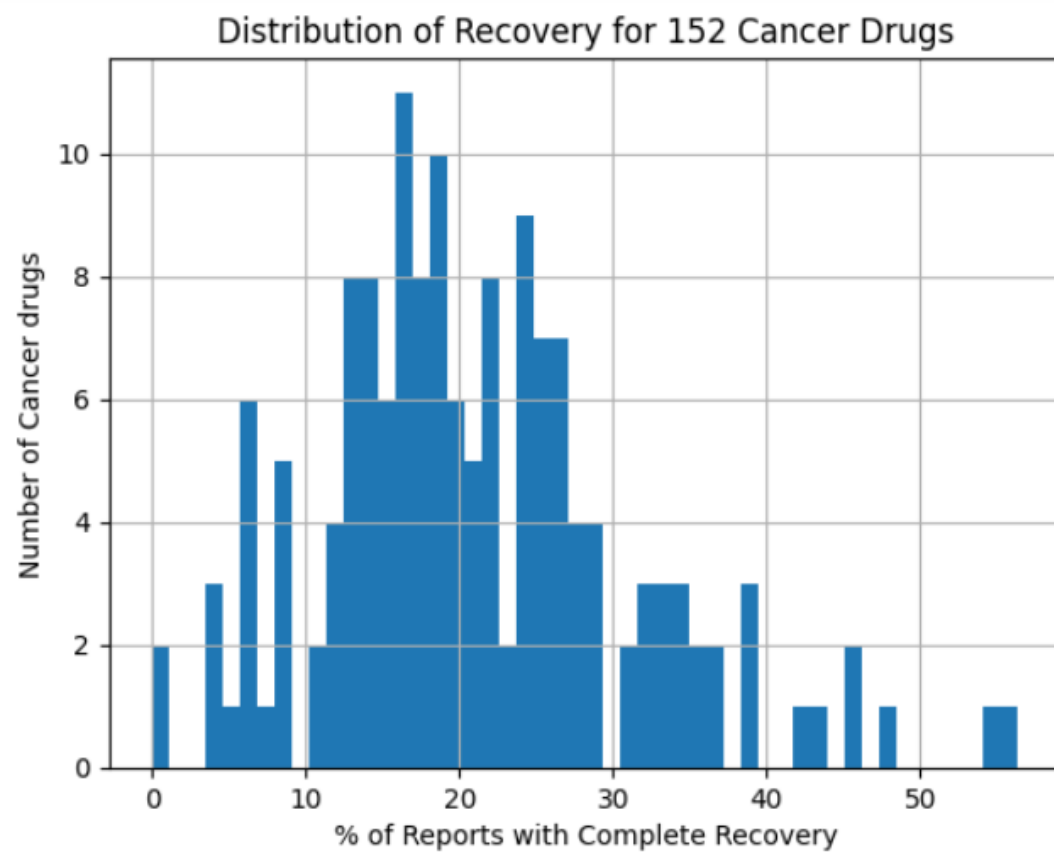
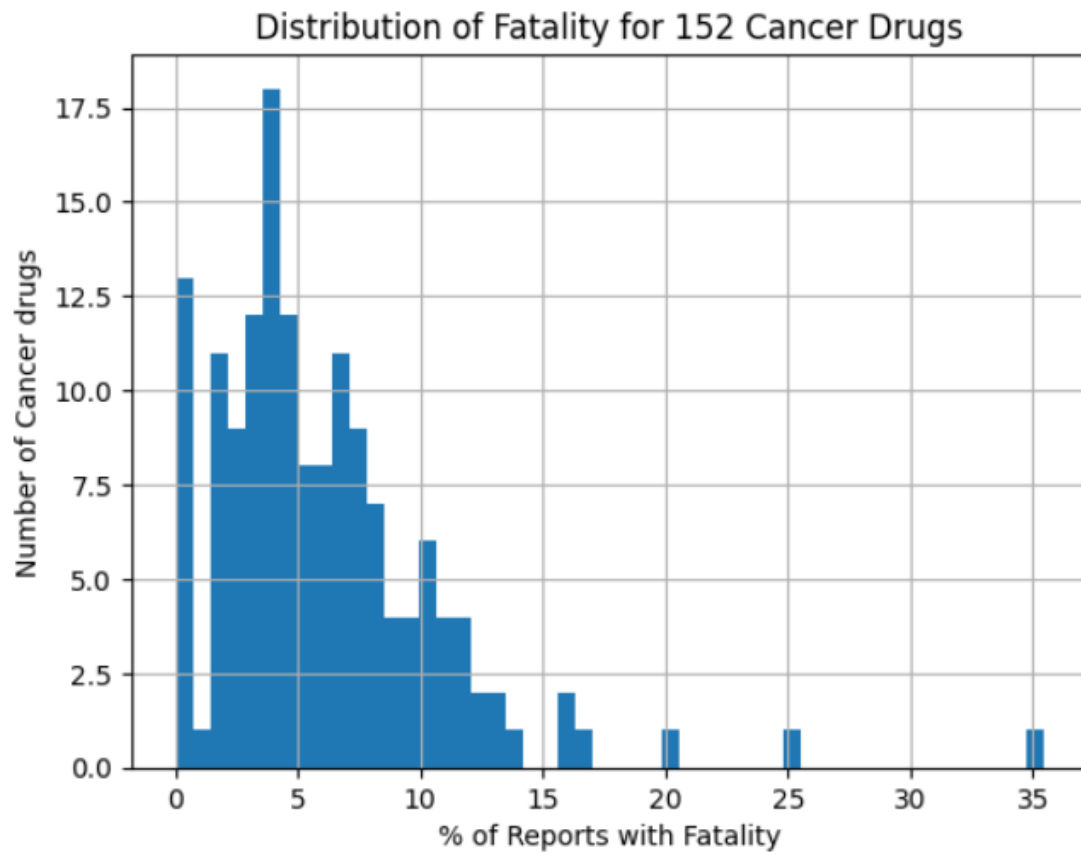
- Recovery 26.45 – 43.09
- Improvement 14.76 – 26.79
- No recovery 6.94 – 10.23

EXCELLENT

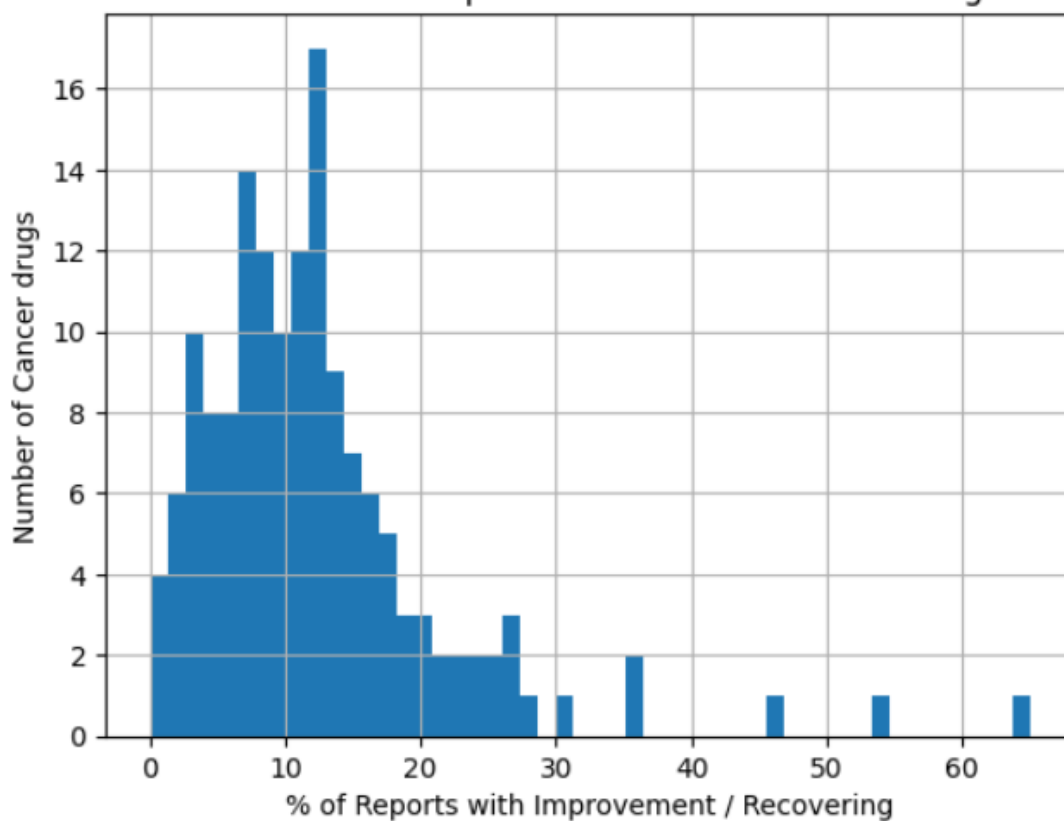
(Outliers)

- Recovery > 43.09
- Improvement > 26.79
- No Recovery < 6.94

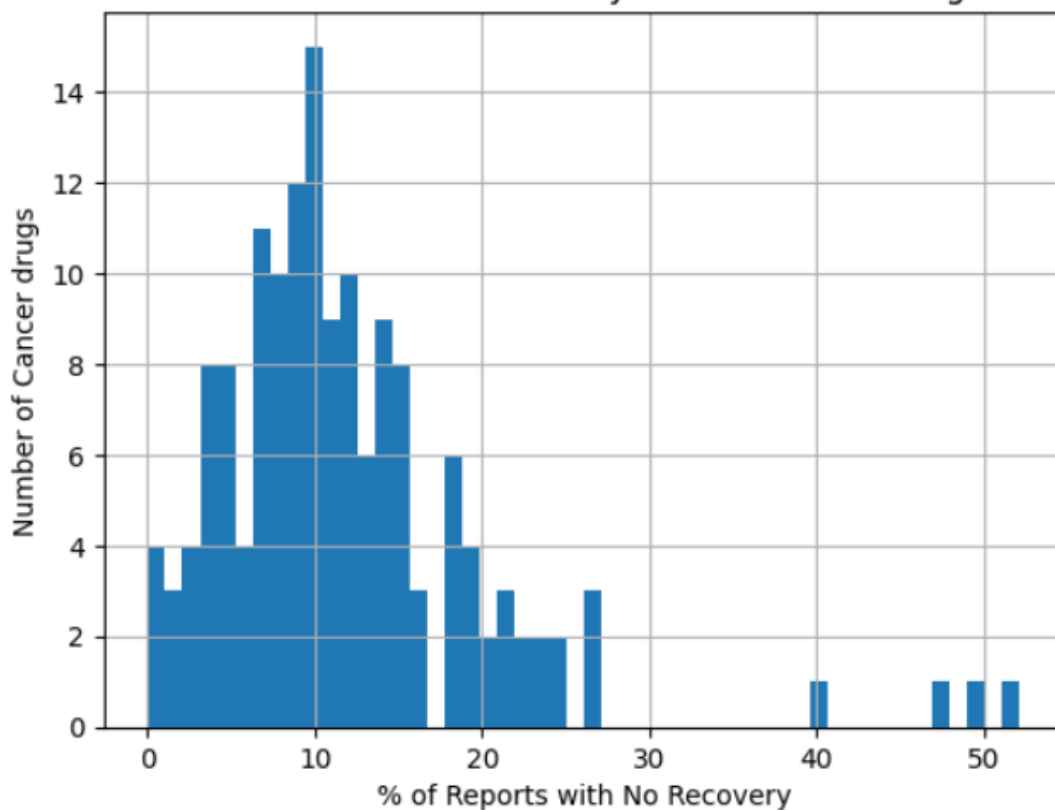




Distribution of Improvement for 152 Cancer Drugs



Distribution of No Recovery for 152 Cancer Drugs



WELL-BEING

The extreme adverse outcomes of fatality, life-threatening events, or hospitalization are not the only effects of concern to drug recipients.

In addition to these critical symptoms, there are general symptoms that effect well-being, such as the incidence of pain, nausea and fatigue, that determine quality of life during treatment. To what extent do different cancer drugs -

- **NAUSEA** : make you nauseous ?
- **PAIN** : cause pain ?
- **FATIGUE** : make you tired ?
- **DIARRHEA** : cause diarrhea
- **HAIR LOSS** : cause hair loss ?

Finally we should be cognizant of any symptoms of chronic injury resulting from the medications. Whilst curing one disease (cancer) do these medications give rise to new diseases or illnesses ? To what extent do different cancer drugs -

- **NEUROPATHY** : cause neuropathy ?
- **NERVE DAMAGE** : nerve damage - tingling, burning, weakness or numbness in the hands and/or feet ?
- **ANAEMIA** : cause anemia - a low red blood cell count ?
- **INFECTION** : cause loss of immune cells resulting in more infections ?
- **MEMORY-LOSS** : cause "Chemo-brain" - difficulty with remembering ?
- **COGNITIVE IMPAIRMENT** : difficulty processing information ?
- **CARDIOMYOPATHY** : Chest pain, arrhythmia, palpitations, tachycardia ?

I have created an extended spreadsheet for these ailments to help you assess which cancer drugs may impact well-being.

See **Cancer Drug Ratings** - [download](#)

CARDIOPATHY and NEUROPATHY

As an example of this extended data, those cancer drugs showing highest % for cardiomyopathy are -

- **TRASTUZUMAB**
- **KANJINTI**
- **GRANISETRON**
- **HERCEPTIN**

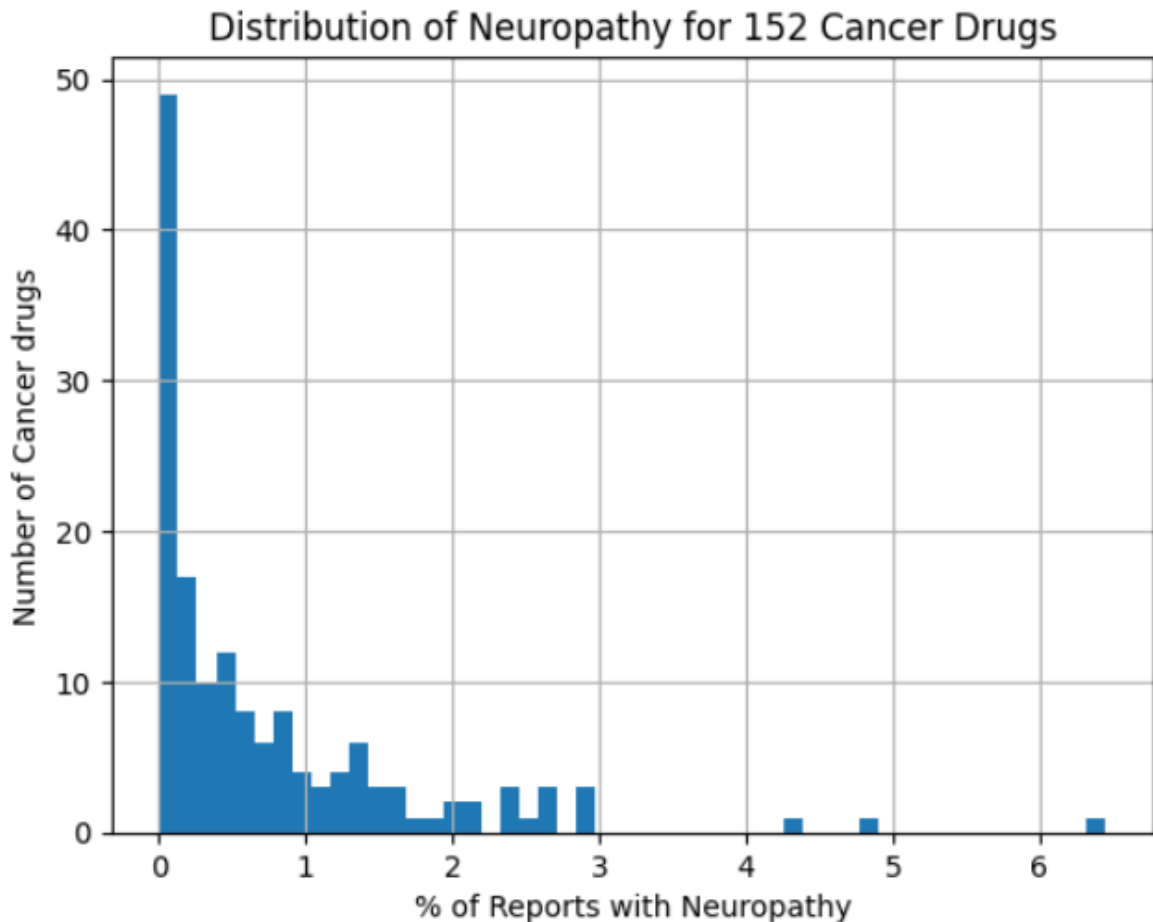
And it so happens that Kanjinti and Herceptin are brand names for Trastuzumab. Clinical literature confirms a strong association with cardiomyopathy.

The datasets results for cardiomyopathy can be cross checked against clinical ratings of cardiomyopathy for these drugs - [Link](#)

Similarly, the cancer drugs showing highest % for neuropathy are -

- **CYTARABINE**
- **PANTITUMUMAB**
- **VECTIBIX**
- **HALAVEN**
- **MVASI**

And it so happens that Vertibix is a brand name for Pantitumumab.



- **count** 152.000000
- **mean** 0.729737
- **std** 0.993755
- **min** 0.000000
- **25%** 0.000000
- **50%** 0.375000
- **75%** 1.010000
- **max** 6.450000

You can see from this chart that the vast majority of cancer drugs cause little neuropathy, but there are 5 that cause a significantly higher incidence.

- The mean score is 0.72 %
- The standard deviation is 0.99 %

So the incidence of neuropathy becomes significant at about 2.7%. There are five cancer drugs with higher incidence of neuropathy than this.

Even so, most people would prefer a cancer drug closer to the mean, or below the mean, when a poor choice can lead to chronic mental impairment.

MONOCLONAL ANTIBODIES

Monoclonal antibodies are antibodies created in a lab that only target cancer cells. Theoretically, monoclonal antibodies should have fewer adverse effects compared to chemo, since MABs are supposed to leave healthy cells alone.

However, in reality there is some overlap where the MABs bind to healthy cells too. This can be seen in the variation in the level of cardiomyopathy with different MABs.

Drug	% Cardiomyopathy
PANITUMUMAB	1.56
BEVACIZUMAB	1.16
NIVOLUMAB	2.28
CETUXIMAB	0.62
TRASTUZUMAB	14.25
PERTUZUMAB	5.44
DENOSUMAB	2.1
RITUXIMAB	2.1
IPILIMUMAB	3.31
AVELUMAB	2.91
SACITUZUMAB	0.31

Drug	% Neuropathy
PANITUMUMAB	4.82
BEVACIZUMAB	2.66
NIVOLUMAB	2.41
CETUXIMAB	2.36
TRASTUZUMAB	1.64
PERTUZUMAB	1.28
DENOSUMAB	0.99
RITUXIMAB	0.7
IPILIMUMAB	0.5
AVELUMAB	0.46
SACITUZUMAB	0

Whilst Sacituzumab has the lowest incidence for both cardiomyopathy and neuropathy, they both have high rates of fatality and low rating for recovery from cancer.

Rituximab however has the highest rate for recovery and improvement out of all the MAB drugs. It also has low fatality, low pain, low fatigue, and low neuropathy ratings.

ANAEMIA

Cancer drugs with the highest % for anaemia are -

Drug	% Anaemia
LYNPARZA	14.61
LUTETIUM	12.5
OLAPARIB	9.47
HYCAMTIN	7.41
TRABECTEDIN	6.03
TOPOTECAN	4.62

This is confirmed by medical literature -

"Lynparza treatment commonly causes anemia, a blood disorder in which your red blood cell levels become low. Anemia was one of the more common side effects seen in clinical trials of the drug. Anemia from Lynparza may be mild to severe. Red blood cells work to carry oxygen throughout your body" [Source](#)

Lynparza is a brand name for Olaparib. Notice that both of these drug names occur in the top 3 ranks !

Olaparib has a strong association with anaemia - [Source](#)

Hycamtin is also strongly associated with anaemia.

"Anaemia Moderate to severe (Hb $\leq$ 8.0 g/dl) in 37% of patients (14% of courses). Red cell transfusions were given in 52% of patients (21% of courses). Frequently reported non-haematological effects were gastrointestinal, such as nausea (52%), vomiting (32%), diarrhoea (18%), constipation (9%) and mucositis (14%)."

The active ingredient in Hycamtin is Topotecan. Notice that these two drugs occur with ranks 4 and 6 respectively ! - [Source](#)

Lutetium (Lu 177) is also strongly associated with anaemia. Lutetium is a radiation treatment.

"This medication decreases bone marrow function, an effect that may lead to a low number of blood cells such as red cells, white cells, and platelets. **This effect can cause anemia,** decrease your body's ability to fight an infection, or cause easy bruising/bleeding." - [Source](#)

Other radiation treatments are Pluvicto (which includes Lutetium), and Xofigo, that includes radium.

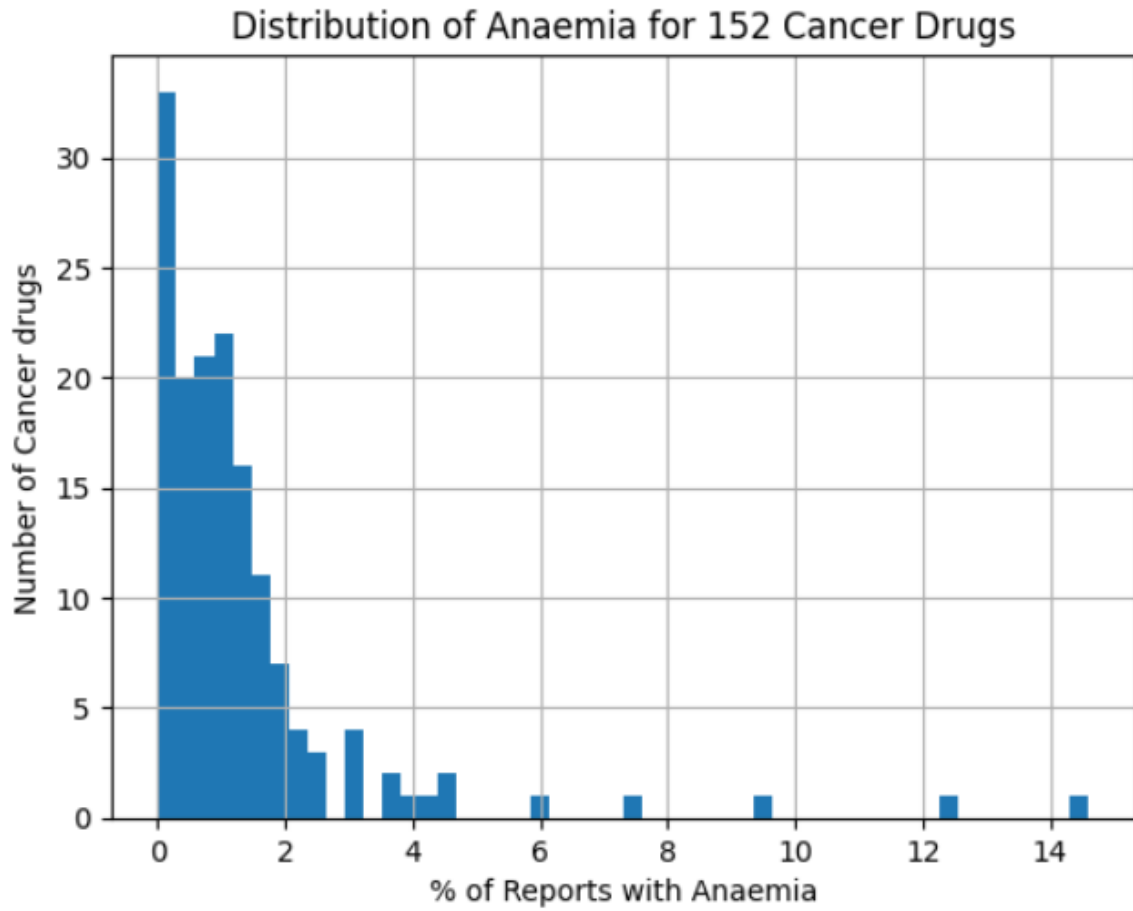
These radiation treatments are all strongly associated with anaemia. Here is the list of cancer drugs again, sorted in order of anaemia -

Drug	% Anaemia
LYNPARZA	14.61
LUTETIUM	12.5
OLAPARIB	9.47
HYCAMTIN	7.41
TRABECTEDIN	6.03
TOPOTECAN	4.62
1	4.49
XOFIGO	4.36
GRANISETRON	3.88
ONTRUZANT	3.71
PLUVICTO	3.68
LONSURF	3.21
PEMETREXED	3.2

I have highlighted the drugs that are radiation treatments. These drugs are carried into the bone marrow, where their radioactive cargo destroys the cancer cells, but also destroys stem cells that generate red blood cells leading to anaemia.

The above examples of anaemia show the effectiveness of this dataset in identifying cancer drugs that cause anaemia. Even when a drug or treatment is under different brand names, they appear in close proximity of rank to one another.

Many people might assume that anaemia is the inevitable result of any cancer treatment. However, this is not the case. In the following graph you will see that most cancer drugs have only a small anemic effect - so identifying the safer ones and discussing alternatives can make a difference.



- count 152.00000
- mean 1.33875
- std 1.95699
- min 0.00000
- 25% 0.39750
- 50% 0.90500
- 75% 1.48500
- max 14.61000

You can see from this chart that the vast majority of cancer drugs cause little anaemia, but there are 5 that cause a significantly higher incidence.

- The mean score is 1.3 %
- The standard deviation is 1.95

So the incidence of anaemia becomes significant at about 5.2%. There are five cancer drugs with higher incidence of anaemia than this.

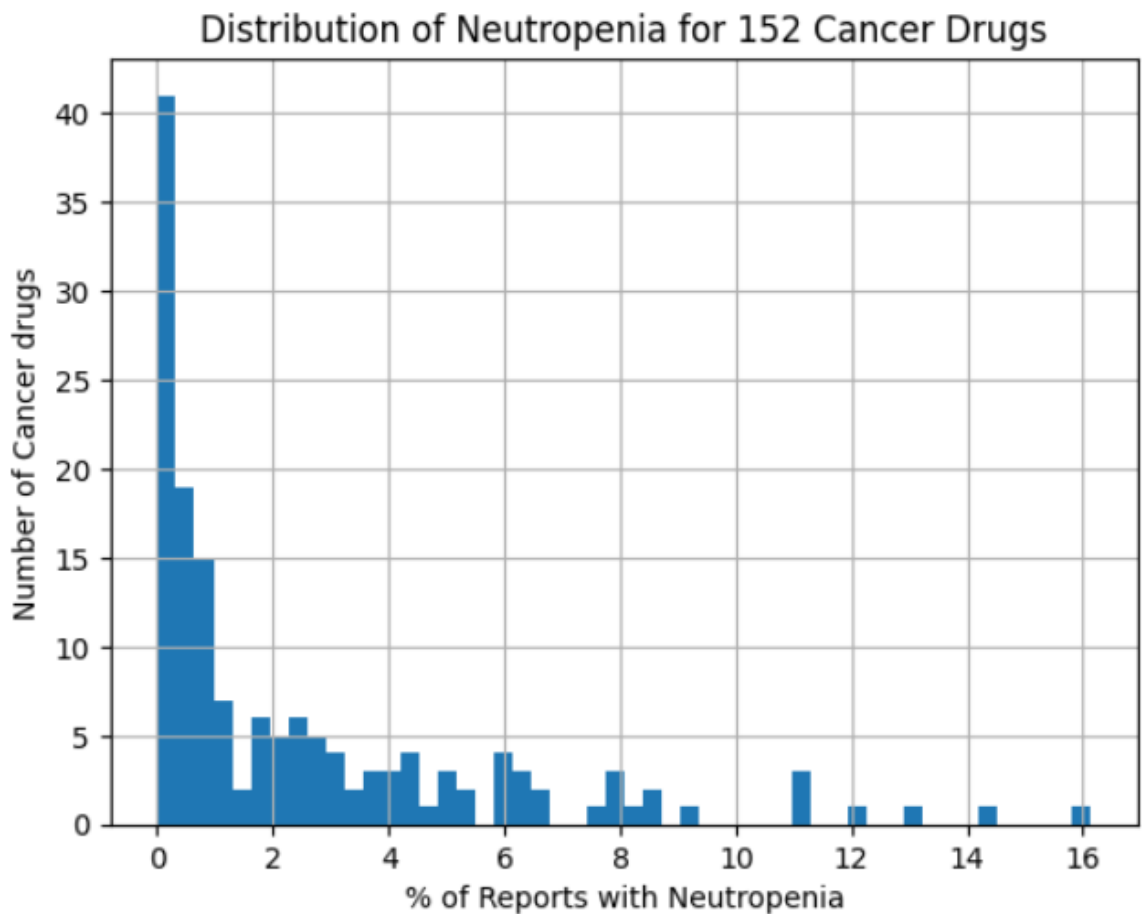
Most people would prefer a cancer drug closer to the mean, or below the mean, when a poor choice can lead to anaemia resulting in chronic fatigue, bruising, bleeding and infection.

Anaemia arises because the cancer drug attacks the bone marrow preventing new blood cells from being created.

IMMUNE DEFICIENCY (NEUTROPENIA)

This is depletion of immune cells called neutrophils – your first line of defence against bacterial, viral and fungal infections.

Depletion of these immune cells will allow pathogens to multiply in your body – which can result in infection and sepsis.



- count 152.000000
- mean 2.523092
- std 3.247471
- min 0.000000
- 25% 0.227500
- 50% 1.000000
- 75% 3.825000
- max 16.140000