ITMO

# AIDS

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# AIDS

In the U.S., most people with HIV (virus that attacks cells that help the body fight infection, making a person more vulnerable to other infections and diseases) do not develop AIDS because taking HIV medicine as prescribed stops the progression of the disease.

Global HIV statistics

- 39.0 million [33.1 million–45.7 million] people globally were living with HIV in 2022.
- 1.3 million [1 million–1.7 million] people became newly infected with HIV in 2022.
- 630 000 [480 000–880 000] people died from AIDS-related illnesses in 2022.

# Purpose and objectives of study

## Goal

Is AIDS an Invariably Fatal Disease?

## Objectives

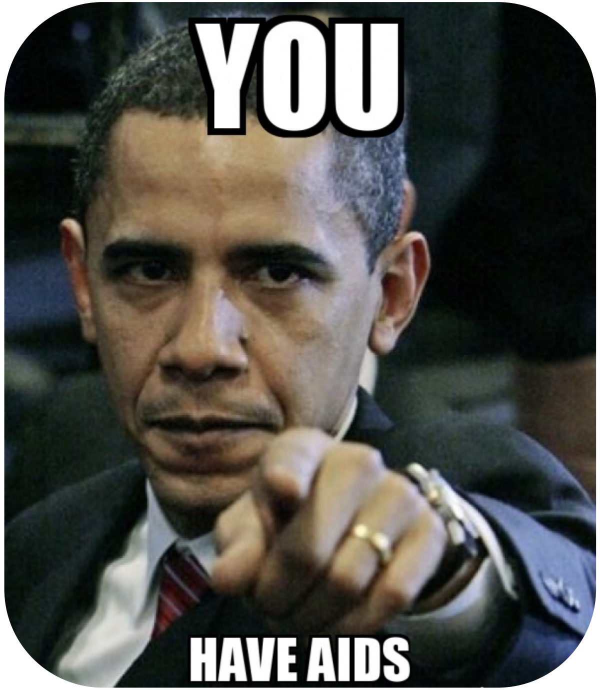
Replicate stuff from the Article by Ivan Kramer

- Check related problems
    1. Show that average survival time $T_{aver}$ after AIDS diagnosis for a member of this cohort is given by 1/k
    2. What fraction of the cohort survived 5 years after AIDS diagnosis?
    3. Fraction aids:
        - Show that S(t) can be written in the form $S(t) = 2^{-t/T_{1/2}}$
        - Show that $T_{1/2} = T_{aver}$
    4. What fraction of lung cancer patients survives two years with the disease?

# Problem

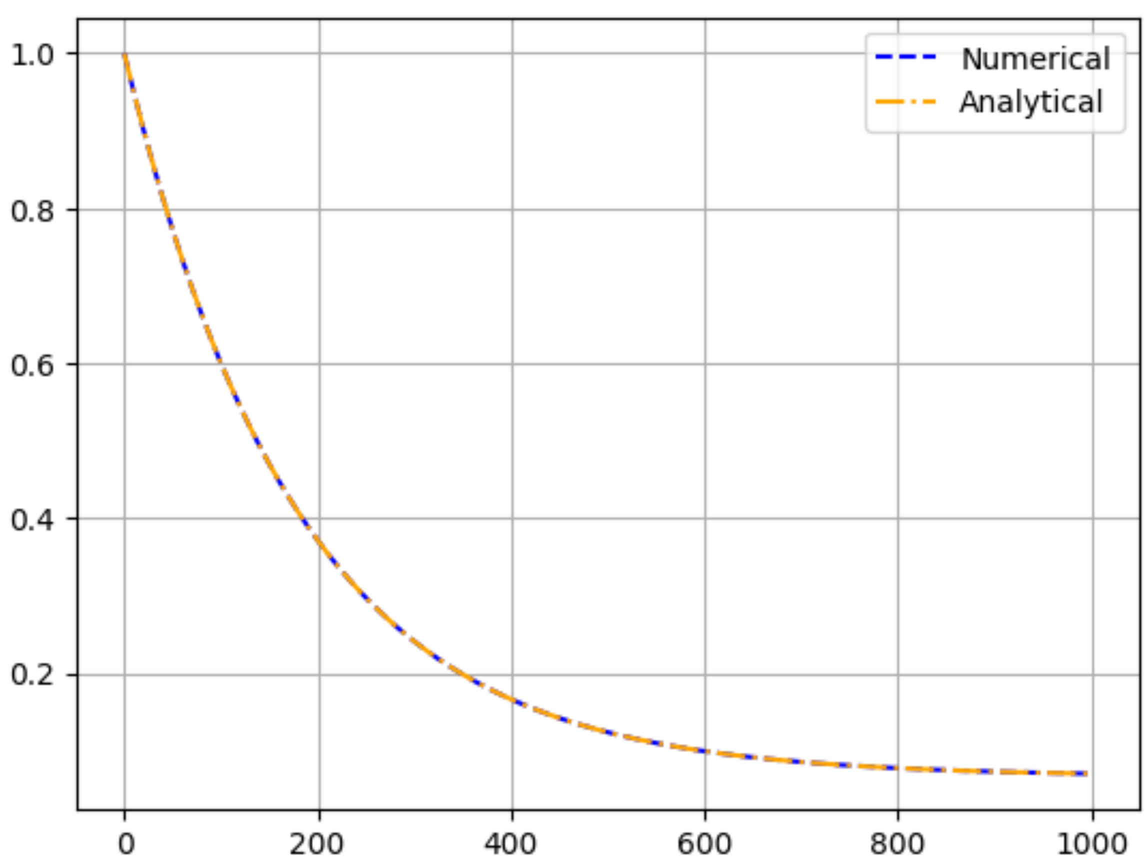
Is AIDS an Invariably

Fatal Disease?




Barack Hussein Obama II 44th President of the United States

# Replication of article results



## Related problem 1

$$S = S_0 e^{-kt}$$

$$f(t) = e^{-kt}$$

# Related problem 1

$$T_{aver} = \frac{\int_{-\infty}^{+\infty} x \cdot f(x)dx}{\int_{-\infty}^{+\infty} f(x)dx}$$

$$\int_{-\infty}^{0} t \cdot f(t)dt = 0$$

# Related problem 1

$$T_{aver} = \frac{\int_0^\infty te^{-kt}dt}{\int_0^\infty e^{-kt}dt} = \frac{\int_0^\infty te^{-kt}dt}{-\frac{1}{k}e^{-kt}\Big|_0^\infty} = \frac{\int_0^\infty te^{-kt}dt}{-\frac{1}{k}(0-1)} = k\int\limits_0^\infty te^{-kt}dt$$

# Related problem 1

$$T_{aver} = k\int_0^{\infty} te^{-kt}dt = -te^{-kt}\Big|_0^{\infty} + \int_0^{\infty} e^{-kt}dt$$

$$T_{aver} = -(0-0) - \frac{1}{k}e^{-kt}\Big|_0^{\infty} = -\frac{1}{k}(0-1) = \frac{1}{k}$$

# Related problem 2

$$S(t = 60) = e^{-0.15625*60} = e^{-9.375} \approx 8.48 * 10^{-5}$$

# Related problem 3

$$S\left(t = T_{1/2}\right) = e^{-kT_{1/2}} = \frac{1}{2}$$

$$\ln e^{-kT_{1/2}} = \ln\frac{1}{2}$$

$$T_{1/2} = \underbrace{\frac{1}{k}}_{T_{aver}} * \ln 2$$

$$T_{1/2} = T_{aver} * \ln 2$$

## Related problem 3

$$\left.\begin{aligned} S(t) &= e^{-kt} \\ T_{aver} &= k^{-1} \end{aligned}\right\} \to S(t) = e^{-t/T_{aver}} = \exp\left(-\frac{t \ln 2}{T_{\frac{1}{2}}}\right)$$

Let’s change the base:

$$S(t) = \left(e^{\ln 2}\right)^{-t/T_{1/2}} = 2^{-t/T_{1/2}}$$

# Related problem 4

$$\frac{dS(t)}{dt} = -k(S(t) - S_i)$$

$$S(t) = S_i + (1 - S_i)e^{-kt}$$

# Related problem 4

$$S(t = 60) = 0.1 + 0.9 * e^{-k*60} = 0.14$$

$$k = -\frac{\ln\left(\frac{2}{45}\right)}{60}$$

# Related problem 4

$$S(t=60) = 0.1 + 0.9 * e^{t\frac{\ln\left(\frac{2}{45}\right)}{60}} = 0.1 + 0.9 * \left(\frac{2}{45}\right)^{t/60}$$

$$S(t=24) = 0.1 + 0.9 * \left(\frac{2}{45}\right)^{\frac{2}{5}} \approx 0.359$$

# Research Summary

- Replicated the article results
- Showed that
  - average survival time is given by 1/k
  - fraction of the cohort survived 5 years with AIDS
  - $S(t) = 2^{-t/T_{1/2}}$ and $T_{1/2} = T_{aver}$
  - 0.359 of lung cancer patients survives two years with the disease

# Resume


AIDS is Invariably
Fatal Disease

# References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[3] Easterbrook, Philippa J., Emani Javad, Moyle, Graham, Gazzard, Brian G. Progressive CD4 cell depletion and death in zidovudine-treated patients. JAIDS, Aug. 6, 1993, No. 8: 927-929.

[4] Kramer, Ivan. The impact of zidovudine (AZT) therapy on the survivability of those with progressive HIV infection. Mathematical and Computer Modelling, Vol. 23, No. 3, Feb. 1996: 1-14.

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# THANK YOU FOR YOUR TIME!

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