The Promise of mRNA Cancer Vaccines: Potential Lives Saved and Economic Value in the US

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Abstract

Background: The messenger RNA (mRNA) vaccine development platform played a central role preventing millions of deaths during the COVID-19 pandemic. Beyond infectious diseases, mRNA vaccines are showing promise in oncology, where early-phase clinical trials report meaningful improvements in overall and recurrence-free survival. However, the United States (US) Department of Health and Human Services recently announced plans to curtail investment in this revolutionary technology. Therefore, evaluation of the potential public health and economic value of the messenger RNA (mRNA) vaccine development platform is critical for informing funding decisions.

Methods: We reviewed ongoing mRNA cancer vaccine clinical trials and extracted survival outcomes. Combining these trial-based improvements with incidence and demographic-adjusted survival rates from the Surveillance, Epidemiology, and End Results (SEER) program of National Cancer Institute, we projected likely future impacts of mRNA vaccination technology on cancer alone. A logistic regression framework estimated one- and three-year survival gains. We then applied the Value of a Statistical Life Year (VSLY, $604,000; 3% discount rate) provided by the US Department of Health and Human Services to quantify the economic implications of forgoing mRNA investment.

Results: In a single annual U.S. cohort of patients newly diagnosed with non-small cell lung cancer, pancreatic cancer, renal cell carcinoma, or melanoma, mRNA vaccination could potentially avert approximately 49,000 deaths within three years of diagnosis. These projected survival gains translate to an estimated economic value of $75 billion.

Conclusions: Our findings demonstrate the substantial public health opportunity provided by mRNA cancer vaccines. Curtailing federal investment risks forfeiting these benefits. In contrast, sustained support could accelerate clinical translation as well as preserve infrastructure essential for future pandemic preparedness.

Introduction

In August 2025, the United States (US) Department of Health and Human Services announced it would cease federal investment in messenger RNA (mRNA) vaccine development, with the Biomedical Advanced Research and Development Authority (BARDA) cancelling more than $500 million in ongoing contracts.[1] This decision comes at a pivotal moment for the field. While public funding was instrumental in accelerating mRNA vaccine development for COVID-19, which prevented millions of deaths and saved hundreds of billions in healthcare costs,[1,2] the withdrawal of support risks undermining progress in transformative oncology treatments.

Messenger RNA vaccines have emerged as one of the most powerful biomedical innovations of the past decade.[2,3] Their unique advantages over traditional vaccine technologies include rapid design, scalability, and adaptability to both infectious and non-infectious diseases.[3,4] Unlike conventional vaccines that rely on attenuated or inactivated pathogens, mRNA vaccines deliver genetic instructions that enable the body to produce antigens internally, eliciting strong immune responses with remarkable speed and flexibility.[2] The success of COVID-19 vaccines highlighted not only their capacity to avert large-scale mortality and morbidity but also their unparalleled economic return on investment.

Recent advances in our understanding of the role of immune response in cancer surveillance and suppression have inspired investigations into the application of mRNA vaccines that evoke response to tumor neoantigens as a cancer treatment.[5–11] Early results indicate that mRNA vaccines can provide substantial improvements in overall survival, recurrence-free survival, and progression-free survival compared to standard therapies.[12,13] However, recent curtailing of federal investment at this juncture jeopardizes not only the translation of ongoing trials into approved therapies but also the infrastructure required to sustain rapid vaccine design and manufacturing capacity.[14,15]

In this study, we evaluated the potential public health and economic benefits of mRNA cancer vaccines using preliminary trial results and national cancer data.[16,17] Specifically, we reviewed ongoing and completed US-based trials, modeled potential survival gains for selected cancers, and quantified the associated economic value of continued investment in this platform.

Methods

We estimated the potential public health and economic benefits of mRNA vaccines in treating cancer patients using clinical trial data. First, we conducted a systematic review to identify clinical trials investigating mRNA vaccines for oncology treatment. From these studies, we extracted survival data for four cancer types with promising preliminary results: non-small cell lung cancer (NSCLC), pancreatic cancer, renal cell carcinoma (RCC), and melanoma. We then quantified the survival benefit from mRNA vaccination treatment by employing a logistic regression model to compare trial-derived overall survival (OS) rates with demographically adjusted baseline OS rates derived from the Surveillance, Epidemiology, and End Results (SEER) Program. With the estimated survival benefit from mRNA vaccination treatment, we projected the number of deaths averted within national incidence cohorts and computed the

economic value of lives saved by applying federal valuation benchmarks, discounted over the estimated years of life gained.

Clinical trial identification

We systematically reviewed recent and historical literature reviews, which mapped the current state of mRNA cancer vaccine research both in the US and globally. Trials were classified as "classic" mRNA or dendritic cell-based (DC) mRNA. Classic mRNA vaccines encode tumor-specific antigens into mRNA, which are then translated into proteins by the patient's immune cells.[18] In contrast, mRNA-DC vaccines involve the removal of DCs from the individual receiving treatment, which are then electroporated with tumor-attacking mRNA, and injected back into the body.[19] In total, we found over 40 clinical trials investigating a wide range of cancers, including melanoma, prostate cancer, and brainstem gliomas.[20] Over half of these trials are conducted in the US, with China, Germany, and the Netherlands hosting the majority of the rest.[20] We identified studies that had extractable OS data suitable for quantitative projection. This process identified four cancers: NSCLC, pancreatic cancer, RCC, and melanoma. We conducted our lives-saved and economic valuation analysis for these four cancers. To understand how funding cuts in the US can impact the progress of mRNA vaccines, we also screened all trials, focusing on those currently being conducted and funded within the US.

Estimation of survival benefits

Data Extraction and Kaplan-Meier (KM) Analysis

Survival curves reported in the selected clinical trials were digitized to obtain time-to-event data points. OS rates and associated 95% confidence intervals (CI) for patients receiving the mRNA vaccine were then computed for one, three, five, and ten years (depending on data availability) using the Kaplan-Meier method.

Baseline Survival Estimation (SEER Data)

We estimated a baseline OS rate for each cancer type, reflecting survival in the absence of mRNA vaccination (or standard of care). For this approximation, we utilized age, sex, stage of cancer, and cancer-subtype specific OS rates reported in the SEER database for a year similar to the study period (**Table S1–S5**). These rates were then weighted based on the specific demographic and clinical characteristics reported within the respective clinical trial publications. For studies that included a control group (e.g., Melanoma), the control group's survival rates were also incorporated as a representative baseline.

Modeling the effect of mRNA vaccination

For each cancer, we modeled the effect of mRNA vaccination on the OS rate using a logistic regression approach to estimate the log-odds ratio of survival. For a given duration t (e.g., $t = 1$ year or $t = 3$ years), the relationship between the OS rate with ($q_{mRNA}(t)$) and without ($q_0(t)$) mRNA vaccination was defined as

$$\log\left(\frac{q_{mRNA}(t)}{1-q_{mRNA}(t)}\right) = \log\left(\frac{q_0(t)}{1-q_0(t)}\right) + \beta_{mRNA}, \quad (1)$$

where β_{mRNA} is the log-odds ratio representing the estimated constant survival benefit of the mRNA vaccine.

The parameter β_{mRNA} was estimated by maximizing the log-likelihood function of the observed baseline one and three-year OS rates the log-likelihood of the mRNA-treated one and three-year OS rates (**Appendix**). The survival rate distributions were modeled as Beta distributions (denoted $B(x|a,b)$), parameterized such that the mode was fixed to the reported point estimate and the 2.5th and 97.5th percentiles fit the reported 95% CIs. For studies not having one or three-year OS rates for the mRNA vaccine, we extrapolated the values to approximate the survival rate at the missing year. Uncertainty in the estimate of β_{mRNA} was constructed using Bayesian melding.

The estimated β_{mRNA} was then applied age- and stage-specific SEER survival rates to project the one-year and three-year survival rate with mRNA vaccination for a general population cohort (**Appendix**).

Cancer-Specific Data Sources and Demographic Adjustments

Non-small Cell Lung Cancer

The first patient was recruited in April 2013.[21] Overall, there were 13 males and 13 females enrolled in the study, where the median age was 63.0 years with a range from 40–83 years of age. All patients had stage IV (distant) NSCLC.

Pancreatic Cancer

A total of 16 patients received the mRNA vaccine in combination with other therapies during the span from December 2019 to August 2021.[22] There were 8 responders and 8 non-responders. The median age was 70.5 years (range: 59–80) among responders and 71.5 years (range: 55–76) among non-responders.Among responders, 6 patients were female and 2 were male; among non-responders, 2 were female and 6 were male. Stage distribution for responders was: stage I (localized), *n* = 4; stage II (regional), *n* = 3; stage III (regional), *n* = 1. For non-responders, stage distribution was: stage I (localized), *n* = 1; stage II (regional), *n* = 4; and stage III (regional), *n* = 3. All treated patients were White.

Renal Cell Carcinoma

The study was conducted among two cohorts, with cohort A between August 2003 to June 2004 and cohort B from August 2004 to November 2005. Among cohort A, the mean age of patients was 64.4 years (range: 36–79), and cohort B had an average age of 62.6 years with a (range: 44–73).[23] Among the patients treated with an mRNA vaccine were 73% were male (cohort A: 11/14 were male and cohort B: 11/16 were male). All patients were in Stage IV (distant) RCC.

Melanoma
Within the vaccine-treated group, 65% (70/107) were male, 55.1% (59/107) were under the age of 65 with a median age of 63 and an interquartile range (IQR) of 53–72, and 85% (91/107) were in stage III and 15% (16/107) in stage IV.[24] There were 107 patients who had received the combination treatment of mRNA-4157 and KEYTRUDA, and 50 who received the monotherapy of KEYTRUDA.[24]

Cost

We calculated the average time from diagnosis to death $\hat{\tau}_{c,a,s}$ when treated with mRNA vaccination and the average time from diagnosis to death $\tau_{c,a,s}$ when not treated with mRNA vaccination (**Appendix**). Using the average time of extending life over a three-year period, we applied a 3% discounting rate to compute the life years gained (**Appendix**). Using $604,000 for the central value of a statistical life year, we determined the cost associated with the life years lost over the three-year period due to the cessation of mRNA vaccine treatment (**Appendix**). The overall costs associated with the life years lost in the absence of mRNA vaccination were calculated by aggregating the costs across each age, sex, and stage of cancer.

Results

Between September 8, 2025, and October 3, 2025, we reviewed phase and estimated completion date of clinical trials via ClinicalTrials.gov [25] and published literature, identifying 25 US-based clinical trials or multinational trials with US sites that are currently ongoing or have been completed since 2010, excluding those that are terminated or suspended (**Table 1**). These trials target a wide range of cancers, with melanoma and NSCLC as the primary focus. At the time of review, several candidates are now advancing into late-stage development, with five Phase III or Phase II/III trials targeting malignant melanoma, non-small cell lung cancer, colorectal cancer, head and neck cancer, and cutaneous squamous cell carcinoma expected to conclude between 2026 and 2035.

Early findings from several candidates indicate meaningful clinical benefits, including improved overall survival, reduced cancer recurrence, and delayed disease progression. For example, Moderna and Merck are jointly evaluating the mRNA-4157 neoantigen vaccine in combination with pembrolizumab (Keytruda), with six ongoing trials across five cancers: bladder cancer, kidney cancer, cutaneous squamous cell carcinoma, malignant melanoma, and NSCLC. A 3-year median follow-up analysis from the phase II trial (NCT03897881) showed that mRNA-4157 plus Keytruda reduced the risk of recurrence or death by 49% and the risk of distant metastasis or death by 62% compared to treating with Keytruda alone in malignant melanoma,[26] providing strong justification for expansion into additional cancer types.

Cancer deaths averted through mRNA vaccination treatment

Based on available studies that have reported overall survival rates with mRNA vaccines, which exhibit a promising increase in OS rates for cancer patients (**Table 2**), we focused our analysis on NSCLC, pancreatic cancer, RCC, and melanoma. Assuming all diagnosed patients received mRNA vaccination, we estimated the number of deaths averted among these four cancers compared to no mRNA vaccination within a single annual cohort of patients (**Fig. 1**).

We estimate that among a single cohort of NSCLC, pancreatic cancer, RCC, and melanoma patients, ceasing government investment in the mRNA platform could cost the United States an additional $75.44 (95% CrI: $44.18–$103.32) billion over a three year period.

Non-small cell lung cancer

Using age- and gender-specific rates for non-small cell lung cancer (i.e., adenocarcinoma of the lung and bronchus, large cell carcinoma of the lung and bronchus, as well as squamous cell carcinoma of the lung and bronchus), we estimated an annual incidence of 136792 (95% CrI: 136041–137553). Among these cases, we estimated there to be 50077 (95% CrI: 49762–50389) deaths within one year and 75780 (95% CrI: 75348–76222) deaths within three years since diagnosis in the absence of mRNA vaccination. We estimate that the use of mRNA vaccination to treat non-small cell lung cancer could avert upwards to 17274 (95% CrI: 1261–29635) over one year and 18947 (95% CrI: 1280–35402) over the span of three years.

The estimated costs associated with the lives lost in a single cohort over a three year period due to the absence of mRNA vaccination treatment is $27.85 (95% CrI: $1.99–$49.20) billion.

Pancreatic

Using age and gender specific rates for pancreatic cancer, we estimated an annual incidence of 62999 (95% CrI: 62570–63443). Among these cases, we estimated there to be 39196 (95% CrI: 38921–39528) deaths within one year and 52072 (95% CrI: 51700–52458) deaths within three years since diagnosis in the absence of mRNA vaccination. We estimate that the use of mRNA vaccination to treat pancreatic cancer could avert upwards to 23563 (95% CrI: 12527–32925) over one year and 20075 (95% CrI: 9209–34033) over the span of three years.

The estimated costs associated with the lives lost in a single cohort over a three year period due to the absence of mRNA vaccination treatment is $34.93 (95% CrI: $17.92–$52.06) billion.

Renal cell cancer

Using age- and gender-specific rates for renal cell carcinoma (i.e., renal pelvis and kidney), we estimated an annual incidence of 77724 (95% CrI: 77216–78227). Among these cases, we estimated there to be 8839 (95% CrI: 8735–8947) deaths within one year and 13949 (95% CrI: 13805–14088) deaths within three years since diagnosis in the absence of mRNA vaccination. We estimate that the use of mRNA vaccination to treat renal cell carcinoma could avert upwards

to 4921 (95% CrI: 3054–6358) over one year and 6613 (95% CrI: 3962–8896) over the span of three years.

The estimated costs associated with the lives lost in a single cohort over a three year period due to the absence of mRNA vaccination treatment is $8.50 (95% CrI: $5.20–$11.16) billion.

Melanoma

Using age and gender specific rates for melanoma, we estimated an annual incidence of 95215 (95% CrI: 94619–95832). Among these cases, we estimated there to be 2840 (95% CrI: 2791–2890) deaths within one year and 5008 (95% CrI: 4923–5116) deaths within three years since diagnosis in the absence of mRNA vaccination. We estimate that the use of mRNA vaccination to treat melanoma could avert upwards to 2235 (95% CrI: 1800–2499) over one year and 3691 (95% CrI: 2962–4266) over the span of three years.

The estimated costs associated with the lives lost in a single cohort over a three year period due to the absence of mRNA vaccination treatment is $4.15 (95% CrI: $3.37–$4.75) billion.

Discussion

Here, we have used nationally representative cancer incidence and survival data and early clinical trial results to perform the first projection of lives saved or monetized gains arising from mRNA cancer vaccine research. Based on standard federal economic valuation metrics, we provide an evidence-based estimate of the costs from federal cuts to mRNA vaccine development. The therapeutic progress demonstrated by each of the clinical trials in our analysis has the potential to avert nearly 50,000 deaths, with an economic value of $75 billion. These costs encompass only a single annual cohort of patients treated for their respective cancer. Disinvestment in mRNA oncology research would lead to an accumulation of avertable deaths and associated costs each year, as a lack of funding defers clinical testing and impedes research progress.

The treatment of cancer with an mRNA vaccine is often paired with other well established treatments. A recent study even identified a strong association between improved survival rates among patients who received an SARS-CoV-2 mRNA vaccine within 100 days before their treatment. [27,28] However, trials have focused on a small subset of supplementing therapies without exploring other potential combinations. Targeted therapy in precision medicine is the selection of a therapeutic drug based on the molecular profile of the cancer. The process involves obtaining a biopsy of the cancerous tissue and identifying key targets of its molecular profile. Given that biopsy and analysis are critical steps in developing an mRNA vaccine for a cancer patient, there is potential to integrate the two approaches seamlessly. The effectiveness of mRNA vaccine treatment combined with precision medicine may further improve the survival rates observed in current clinical trials.

A small sample size likely reduced the statistical significance when evaluating the effectiveness of mRNA-4157 (V940) + Keyturda compared with Keyturda monotherapy. However, our analysis

uses demographic-specific SEER-reported overall survival rates, demographic profiles from mRNA vaccine clinical trials, and overall survival rates reported in those trials to estimate the extent to which mRNA vaccination therapy improves overall survival rates in cancer patients. Among the mRNA vaccines included in our study, we estimated that mRNA vaccination significantly increased the one-year overall survival rate. Our approach is not aimed at replacing the well-established protocols for clinical trials that evaluate relative effectiveness, but rather to supplement the decision to progress to the next phase for those trials in the early stages. Overall, the approach of using large quantities of existing data on well-established treatments may be fruitful for providing insights into the effectiveness of treatments in early trial phases relative to well-established ones.

Across a single annual cohort of NSCLC, pancreatic cancer, RCC, and melanoma patients, we estimated that the cessation of mRNA vaccination treatment could cost the US over $75 billion over three years. However, the current cost of these vaccines is upwards of $100,000 per dose, and treatment often requires multiple doses [29,30]. We have only evaluated the benefits of mRNA vaccination on overall survival rates over three years due to limited data on long-term survival. Continuation of these trials may illustrate long-term improvements in overall survival rates following mRNA vaccination treatment, which would further increase our estimated costs if mRNA vaccination were halted. Moreover, the use of artificial intelligence has shown high potential to improve the efficacy of these vaccines while reducing production costs [31,32]. With continual investment into mRNA vaccines, the expectation is that vaccine production costs will decrease, making the treatment affordable for many patients [33,34].

A loss of funding for mRNA vaccine development will both impact existing clinical trials and hinder future innovation. Moreover, this disinvestment may undermine public trust in vaccines and mRNA technology, which has the potential to progress as a transformative biomedical innovation [35,36]. Given that mRNA vaccines can be applied to treat nearly all cancer types and the burden of cancer is pervasive across demographics, investment in mRNA technology is crucial to ensure the health of all.

The repercussions of curtailing funding for mRNA vaccine development will be far-reaching. Beyond oncology, mRNA vaccines hold considerable promise for the treatment of infectious, metabolic, autoimmune, genetic, and chronic diseases and disorders [36,37]. Future development of mRNA may also include pandemic preparedness efforts, including mRNA vaccine libraries for known pathogens [36,37]. The ability of mRNA vaccines to be redesigned quickly for new variants or novel pathogens, scaled rapidly to millions of doses, and adapted for diverse targets (such as influenza, HIV, or EBV) positions mRNA vaccines as a cornerstone of infectious-disease control. Continued government investment would function not only as healthcare spending but as a high-return insurance policy against future crises.

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Table 1. US-based or multinational mRNA cancer vaccine trials with US sites, as of September 2025.

Trial ID	Phase	Status	Completion Date	Cancer Type	Sponsor
NCT05933577	Phase III	Active, not recruiting	2030-09-26	Malignant melanoma	Merck & Co
NCT04526899	Phase II	Active, not recruiting	2025-12	Malignant melanoma	BioNTech
NCT03815058	Phase II	Completed	2025-01-21	Malignant melanoma	Roche
NCT03897881	Phase II	Recruiting	2029-09-09	Malignant melanoma	Moderna
NCT06305767	Phase I/II	Recruiting	2031-10-20	Bladder cancer	Merck & Co
NCT06534983	Phase II	Recruiting	2034-01-06	Bladder cancer	Roche
NCT06077760	Phase III	Recruiting	2035-12-21	Non-small cell lung cancer	Merck & Co
NCT03164772	Phase I/II	Completed	2021-10-29	Non-small cell lung cancer	Ludwig Institute for Cancer Research
NCT06307431	Phase II	Active, not recruiting	2032-06-08	Kidney cancer	Merck & Co
NCT05141721	Phase II/III	Active, not recruiting	2027-03	Colorectal cancer	Gritstone Bio
NCT04486378	Phase II	Recruiting	2030-08	Colorectal cancer	BioNTech
NCT04161755	Phase I	Active, not recruiting	2025-11-11	Pancreatic cancer	Memorial Sloan Kettering Cancer Center
NCT04534205	Phase II/III	Recruiting	2029-04	Head and neck cancer	BioNTech
NCT04573140	Phase I	Recruiting	2029-07-01	Glioblastoma	University of Florida
NCT06295809	Phase II/III	Active, not recruiting	2026-03-05	Cutaneous Squamous Cell Carcinoma	Merck & Co
NCT05968326	Phase II	Recruiting	2031-01-01	Pancreatic Ductal Adenocarcinoma	Roche
NCT05660408	Phase I/II	Recruiting	2035-10	Recurrent	University of

				Pulmonary Osteosarcoma; Recurrent High-grade Glioma	Florida
NCT06389591	Phase I	Recruiting	2027-12-01	Recurrent Glioblastoma	University of Florida
NCT00639639	Phase I	Completed	2022-06-01	Glioblastoma multiforme	Gary Archer Ph.D., Duke University
NCT03688178	Phase II	Active, not recruiting	2026-03	Glioblastoma multiforme	Annick Desjardins, MD, Duke University
NCT02465268	Phase II	Completed	2023-11-30	Glioblastoma multiforme	University of Florida
NCT04157127	Phase I	Recruiting	2027-12	Pancreatic adenocarcinoma	Diakonos Oncology Corporation
NCT01995708	Phase I	Completed	2022-06-20	Multiple myeloma	Memorial Sloan Kettering Cancer Center
NCT01456104	Phase I	Completed	2023-01-12	Melanoma	Memorial Sloan Kettering Cancer Center
NCT01326104	Phase II	Completed	2025-03-28	Medulloblastoma	University of Florida

Table 2. The overall survival rate for non-small cell lung cancer, pancreatic cancer, renal cell cancer, and melanoma under treatment with and without mRNA vaccination.

Cancer	Treatment	Overall survival		Reference
		Duration	Survival rate	
Non-small Cell Lung Cancer	BI1361849 (CV9202)	1-year	61.5% (95% CI: 42.8%–80.2%)	[21]
	Estimated baseline (2013)		36.7% (95% CI: 35.9%–37.6%)	Estimated
	BI1361849 (CV9202)	2-year	29.6% (95% CI: 11.6%–47.7%)	[21]
	Estimated baseline (2013)		22.0% (95% CI: 21.5%–22.6%)	Estimated
Pancreatic	Autogene cevumeran	1-year	100% (95% CI: 83.8% –100%)	[38]
	Unvaccinated		66.7% (95% CI: 13.3% –100%)	[38]
	Estimated baseline (2019)		63.1% (95% CI: 59.5%–66.6%)	Estimated
	Autogene cevumeran	3-year	75% (95% CI: 53.8%–96.2%)	[38]
	Unvaccinated		0% (95% CI: 0%–52.7%)	[38]
	Estimated baseline (2019)		41.8% (95% CI: 38.1%–45.6%)	Estimated
Renal cell	mRNA vaccine	1-year	70.0% (95% CI: 53.6%–86.4%)	[23]
	Estimated baseline (2004)		36.7% (95% CI: 34.6%–38.9%)	Estimated
	mRNA vaccine	3-year	33.3% (95% CI: 16.5%–50.2%)	[23]
	Estimated baseline (2004)		16.9% (95% CI: 15.3%–18.7%)	Estimated
	mRNA vaccine	5-year	26.7% (95% CI: 10.8%–42.5%)	[23]
	Estimated baseline (2004)		12.7% (95% CI: 11.2%–14.3%)	Estimated
	mRNA vaccine	10-year	10.0% (95% CI: 0%–20.7%)	[23]
	Estimated baseline (2004)		7.5% (95% CI: 6.2%–8.9%)	Estimated
Melanoma	mRNA-4157 (V940) +KEYTRUDA	2.5 year	96.0% (95% CI:91.6%–98.8%)	[39]
	KEYTRUDA		90.2% (95% CI: 80.7–96.7%)	[39]
	Estimated baseline (2019)		79.2% (95% CI: 77.8%–80.6%)	Estimated

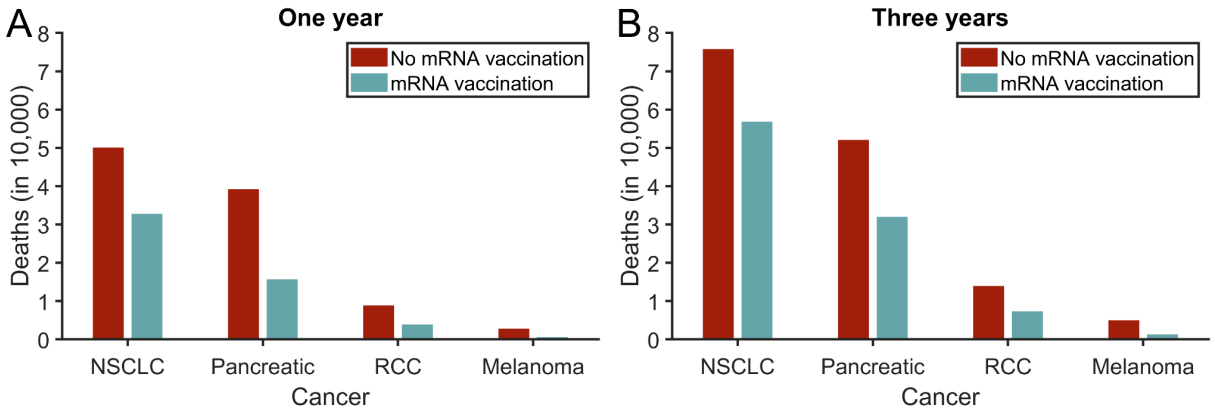

Figure 1: The estimated number of deaths for non-small cell lung cancer (NSCLC), pancreatic cancer, renal cell cancer (RCC), and melanoma with no mRNA vaccination treatment (red) and with mRNA vaccination treatment (green) over a span of (A) one year since diagnosis and (B) three years since diagnosis.