

# Temporal Evolution and Diagnostic Diversification of Patients Receiving Proton Therapy in the United States: A Ten-Year Trend Analysis (2012 to 2021)

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## Introduction

The National Association for Proton Therapy (NAPT) is a non-profit association of medical entities either using proton therapy or actively involved in developing a proton beam therapy program in the United States. The number of proton centers nationally has been growing, with 6 centers operational in 2006, 11 in 2011, 24 in 2016, and 39 by the end of 2021. Currently, there are 45 operating proton centers in the United States. NAPT's member institutions represent 93.4% (n = 42/45) of operational proton therapy centers in the United States.

- There is a clear and pressing need for accurate data regarding the number of patients treated with protons for various diagnoses to help evaluate accrual to these ongoing trials and to help design new trials.
- This will guide health policy decisions, rather than basing such decisions on speculation or outdated/inaccurate legacy data.
- NAPT tracks the number of patients who are treated with protons by using an annual survey designed to collect anonymized information on diagnosis and treatment complexity.

Many articles in medical journals as well as the lay press subsequently zeroed in on this and other reports and, without conducting contemporary and factually accurate data analyses. This suggests that the increase in the number of proton centers was primarily fueled by a focus on prostate cancer treatment where the value proposition for the therapy has been questioned. The perpetuation of inaccurate data does a disservice to the field of radiation oncology as a whole, and rectification of this data accuracy gap is a key goal of this work.

## Methods

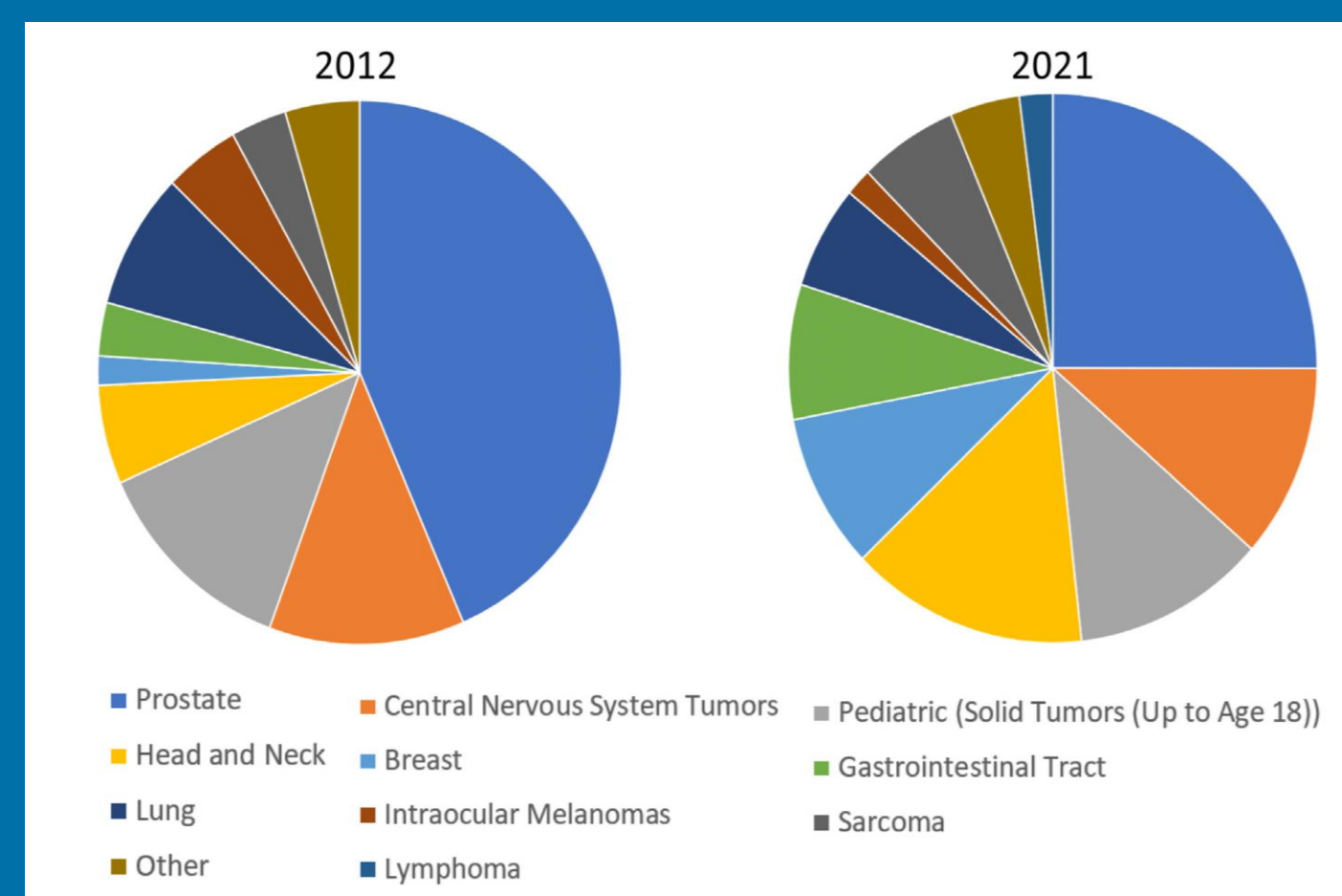
- This survey was first sent out to all members of NAPT in 2015 and covered the time frame from 2012 to 2014. Annual surveys were sent thereafter. Surveys asked comprehensive questions on the number of patients treated by disease site.
- The diseases included prostate cancer, central nervous system tumors, pediatric tumors (up to age 18), head and neck cancer, breast cancer, gastrointestinal tract tumors, lung cancer, intraocular melanomas, base of skull/axial skeleton tumors, female pelvic organ tumors, pituitary neoplasms, urinary tract tumors, unresectable retroperitoneal sarcomas, and "other."
- A second survey component asked about the complexity of treatments, which was defined using the Current Procedural Terminology (CPT) codes for daily proton treatment.
- Each participating institution could participate in a portion of the survey or the entire survey.

### ANALYSIS OF SURVEY RESPONSES

Completed surveys were sent to a third-party consultant where the data was compiled and summarized for analysis and presentation purposes.

## Discussion

Even with this increase in the number of proton centers, the relative penetration of this modality at the local center level in comparison to photon therapy continues to remain very modest, and as a proportion of all external beam radiation therapy fractions delivered, proton therapy continues to hover at less than 2%.



### TREATMENT COMPLEXITY

The complexity of treatments is gradually increasing over time, from simple with compensation to intermediate.

### FRACTION USE

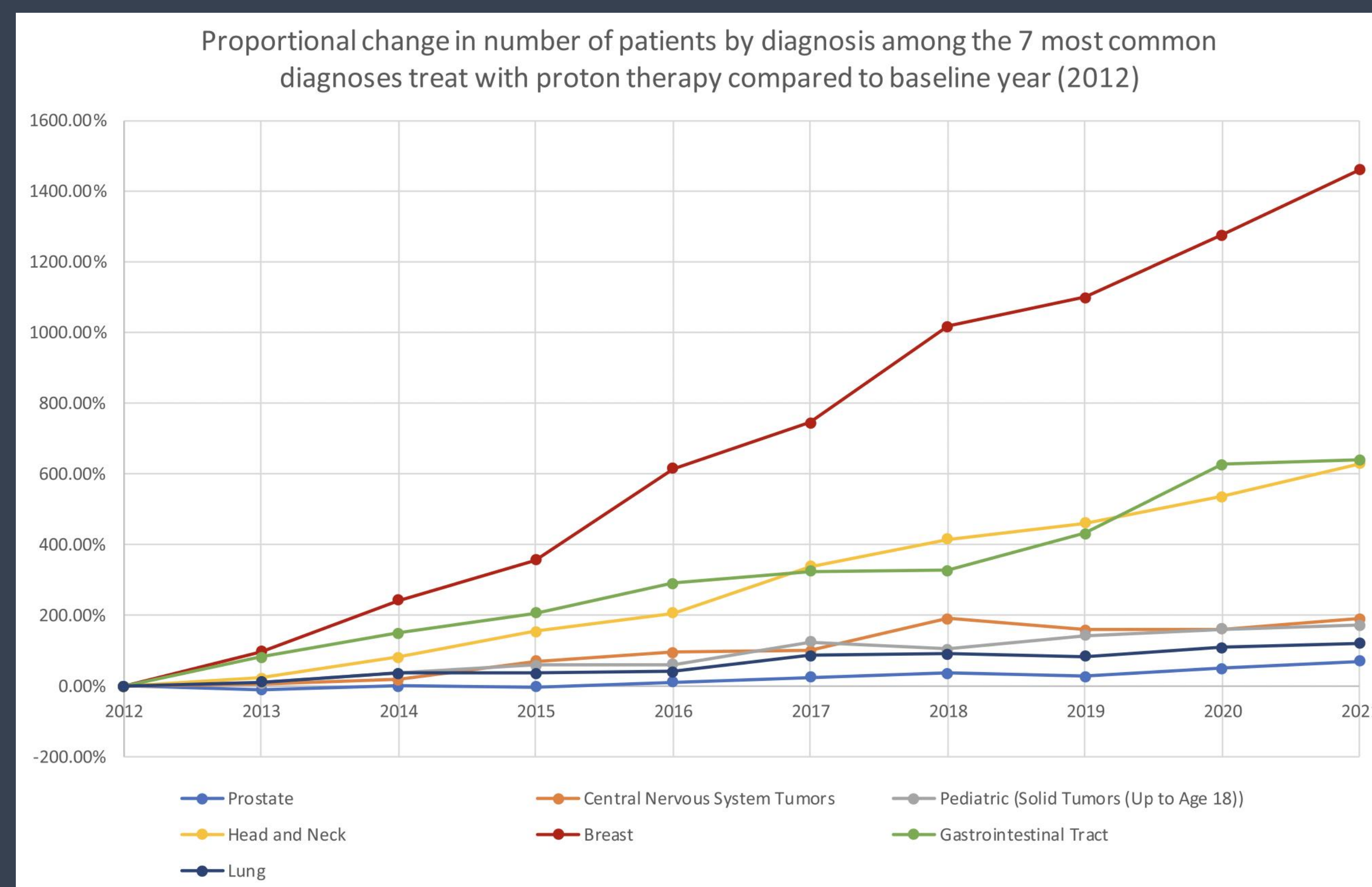
The number of fractions of proton therapy per patient has decreased over this study period, mirroring trends in photon therapy.

### DISEASES TREATED

- There is a significant shift to "new" disease sites treated, especially with an increase in breast, lung, head and neck, and gastrointestinal tumors.
- These are sites for which there are cooperative group randomized trials ongoing, and the wider availability of pencil beam scanning technology allows for the treatment of more complex fields.
- In contrast, there has been a more gradual increase in the number of patients treated with proton therapy for prostate cancer. The use of proton therapy for prostate cancer has significantly declined from 212 patients per center in 2012 to 107 patients per center in 2021, with the proportion of prostate cancer patients treated with protons dropping from 43.4% in 2012 to 25.0% in 2021. The pie charts (left) show the proportion of patients with each diagnosis in 2012 compared with that in 2021.

## Results

Center participation remained above 90% in all years of the survey. The number of participating centers has increased over time, although the proportion of active centers responding has decreased modestly. For the most recent surveys, centers that had recently opened did not respond because of small numbers of patients as well as an early focus on initiating treatments and ramping up while local data collection infrastructure was still nascent. Overall participation was 94.9% in 202 (n = 37/39).



The total number of centers increased from 11 to 37 (a 3.5-fold increase), and the total number of patients treated with protons increased from 5,377 to 15,829 in 2021 (a 2.9-fold increase); when averaged by the total number of treating centers, the number per year per center has decreased somewhat from 489 to 428.

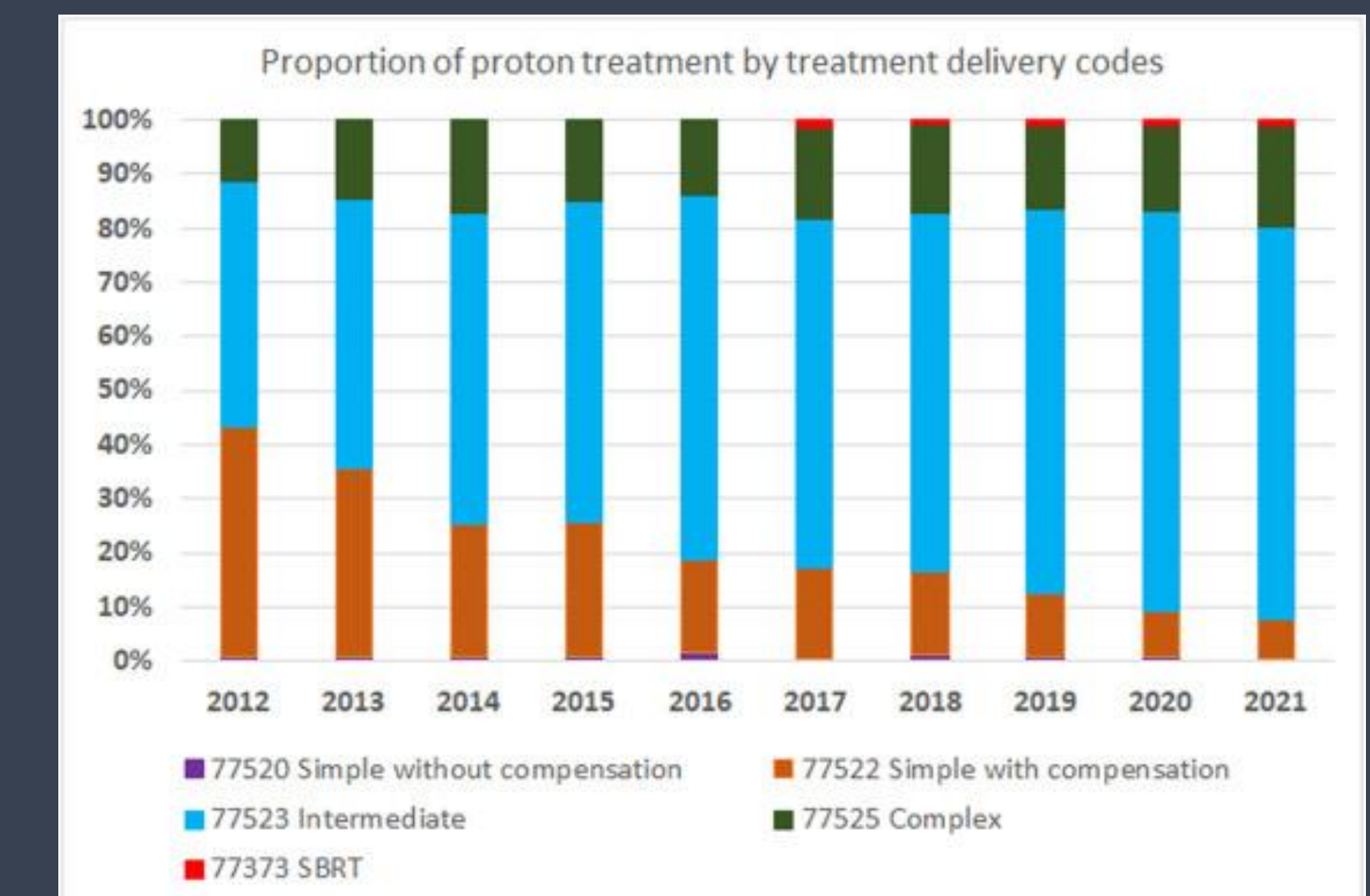
### The first component of the survey asked detailed questions concerning number of patients treated by disease site

The number of patients treated for the "commonly accepted indications" of intraocular melanomas, base of skull tumors, central nervous system tumors (including pituitary neoplasms), and pediatric tumors increased from 1,762 patients in 2012 to 4,449 patients in 2021 (2.5-fold increase). A similar increase was observed in multiple other disease sites, including many of the tumor sites where current prospective randomized trials are available, such as head and neck, lung, gastrointestinal tract, and breast cancers. In the 2012 survey, 1,106 patients were treated with protons for these diagnoses, which increased to 5,979 in 2021 (5.4-fold increase).

## Conclusion

- This 10-year survey data demonstrates an increase in the number of patients treated with proton therapy as the number of proton centers increased, with an evolution in the disease site mix and a decrease in the average fractions per patient.
- The relative percentage of patients treated for prostate cancer has decreased, whereas greater proportional increases were noted for head and neck, breast, and gastrointestinal tumors.
- The average number of fractions per patient treated with proton therapy has declined, similar to the declines observed with photon treatment, whereas treatment complexity has increased.

- 24 responding centers identified themselves as an "academic institution," and 13 responding centers self-reported as a "nonacademic institution."
- Nearly all of the same trends in disease site use were identified between academic and nonacademic institutions as is reported for the overall cohort of responding centers, although the rate of proportional decline in prostate cancer use was higher in nonacademic centers, and the rate of proportional increase in head and neck cancer use was lower in academic centers.



### The second component of the survey involved evaluation of the complexity of treatments.

- The response rate was slightly lower for this component, 82% (9/11) for 2012 and 87.5% (21/24) for 2016.
- There has been a definitive shift in the complexity of treatments during that period. The number of CPT 77522 (simple with compensation) treatments, which would be typical for many prostate cancer patients, decreased from 58,260 fractions delivered in 2012 (43% of total fractions in 2012) to 42,968 treatments in 2016 and declined further to 27,134 in 2021 (7%).
- The number of complex treatments more than doubled (15,369 in 2012-34,439 in 2016, and 68,172 in 2021), but proportionally this was only a minimal increase.
- The number of intermediate-level treatments increased by a factor of 4.3 (62,321-267,843). The average number of fractions per proton therapy treatment course decreased modestly from approximately 25.5 treatments per patient in 2012 to 23.3 fractions per patient in 2021.

## Acknowledgements

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