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ORIGINAL ARTICLE

# The association between telemedicine, advance care planning, and unplanned hospitalizations among high-risk patients with cancer

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## Abstract

**Background:** Despite the widespread implementation of telemedicine, there are limited data regarding its impact on key components of care for patients with incurable or high-risk cancer. For these patients, high-quality care requires detailed conversations regarding treatment priorities (advance care planning) and clinical care to minimize unnecessary acute care (unplanned hospitalizations). Whether telemedicine affects these outcomes relative to in-person clinic visits was examined among patients with cancer at high risk for 6-month mortality.

**Methods:** This retrospective cohort study included adult patients with cancer with any tumor type treated at the University of Pennsylvania who were newly identified between April 1 and December 31, 2020, to be at high risk for 6-month mortality via a validated machine learning algorithm. Separate modified Poisson regressions were used to assess the occurrence of advance care planning and unplanned hospitalizations for telemedicine as compared to in-person visits. Additional analyses were done comparing telemedicine type (video or phone) as compared to in-person clinic visits.

**Results:** The occurrence of advance care planning was similar between telemedicine and in-person visits (6.8% vs. 6.0%; adjusted risk ratio [aRR], 1.25; 95% CI, 0.92–1.69). In regard to telemedicine subtype, patients exposed to video encounters were modestly more likely to have documented advance care planning in comparison to those seen in person (7.5% vs. 6.0%; aRR, 1.48; 95% CI, 1.03–2.11). The 3-month risk for unplanned hospitalization was comparable for telemedicine compared to in-person clinic encounters (21% vs. 18%; aRR, 1.06; 95% CI, 0.81–1.38).

**Conclusions:** In this study, care delivered by telemedicine, compared to in-person clinic visits, produced comparable rates of advance care planning conversations without increasing hospitalizations, which suggests that vulnerable patients can be managed safely by telemedicine.

Ronac Mamtani and Kelly D. Getz are senior authors and have contributed equally to this article.

 

**KEYWORDS**
acute care utilization, advance care planning, end-of-life care, health services, telemedicine

## INTRODUCTION

Telemedicine has recently emerged as a key health care delivery strategy. Although prior work has demonstrated the utility of telemedicine in genetic counseling,[1–7] survivorship,[8,9] and risk reduction initiatives such as smoking cessation,[10] there are limited data regarding the impact of telemedicine on advance care planning and acute care utilization among patients at risk for near-term mortality ("high-risk"). In this population, advance care planning, which consists of discussions about prognosis, goals of care, and priorities at the end of life, has become a quality standard in oncology care.[11,12] Few studies have examined the use of telemedicine in palliative settings, and results from these studies were inconsistent. A small nonrandomized pilot study ($n = 12$) suggested that video conferencing provided greater access to care and was associated with lower mean symptom distress scores compared to in-person visits.[13] In contrast, Hoek et al. found worse symptom distress scores among patients randomized to weekly video consultations with a palliative care specialist in comparison to standard of care.[14] Although these early studies highlight the acceptability and feasibility of telemedicine in cancer care,[12,13,15–19] studies directly comparing in-person and telemedicine visits are limited.[18]

The integration of telemedicine into the clinical workflow for this patient population presents several obstacles; however, quantifying its impact on key components of cancer care, such as rates of advance care planning and acute care utilization, would help guide efforts to improve telemedicine implementation. For example, despite the widespread utilization of telemedicine during the pandemic,[20] controversy still remains regarding the ideal setting for this care delivery strategy, especially when it comes to high-risk patients with cancer.[12,17,21–23] Work by Tevaarwerk et al. analyzing survey responses from 1038 oncologists found that whereas most oncologists felt favorably toward incorporating telemedicine into some aspects of their patient care, clinical scenarios requiring patient–provider connection were better served by an in-person visit.[13] Likewise, Stavrou et al. found that of 71 breast medical oncologists, 74% felt in-person visits better facilitate connection with patients and 63% felt they improve the quality of communication.[24] The lack of physical examination has also raised concerns in the oncology community regarding the safety of telemedicine in patient care and the risk for missed cancer or treatment toxicity.[13,17,23,24] Furthermore, patients who lack access to or competency with video communication technology may be limited to telephone-based care, which could significantly diminish the quality of their discussions and clinical assessment.[17,25–30] Recently published work has demonstrated discrepancies in access to telemedicine, especially video-enabled visits, among patients who are racial minorities, older, and of lower income.[25,31–35] In recognition of these obstacles, the objective of this work is to assess the use of telemedicine among high-risk patients with cancer and quantify its potential impact on advance care planning and unplanned hospitalizations compared to in-person visits.

## MATERIALS AND METHODS

This cohort study compared documented advance care planning and unplanned hospitalization rates between patients receiving telemedicine and those receiving in-person care with EPIC (Epic Systems Corporation, Verona, Wisconsin) electronic health record (EHR) data from the University of Pennsylvania. The University of Pennsylvania EHR provides integrated health care data across multiple clinical centers representing a range of practice models, including a large academic center and community oncology practices. Included were adult patients diagnosed with cancer treated within the University of Pennsylvania health system and newly identified to be at the end of life between April 1 and December 31, 2020. Patients at the end of life were defined as those with a high risk of 6-month mortality and identified via a validated machine learning algorithm.[36] We focused on this population because of the high potential impact, and likely differential effect, of telemedicine on clinical and patient outcomes compared to a less vulnerable population.

The primary exposure was receipt of telemedicine (video- or phone-based) versus a standard in-person visit, defined by the first clinical encounter after patient identification as high-risk.

The primary outcomes were documentation of advance care planning and, separately, unplanned hospitalization in the EHR. Advance care planning documentation included code status discussions as well as detailed serious illness conversations (SICs), which is a standard quality metric in oncology practice.[37] Any documented note in the EHR advance care planning section was considered as advance care planning. Documentation of advance care planning in the EHR is a guideline-based quality standard and the primary mechanism by which goals of care communication get translated into practice.[38,39] As such, it is a reliable proxy for advance care planning and has been successfully used in prior studies with the University of Pennsylvania EHR.[36,37,40] Unplanned hospitalizations were identified from inpatient encounters within the University of Pennsylvania system identified in the EHR; planned hospitalizations, such as scheduled inpatient chemotherapy, were excluded.

After identification as high-risk, patients were followed from the first clinical encounter (e.g., index date) until outcome occurrence or the earliest of 3 months of follow-up, death, or April 1, 2021 (date of data extraction from the EHR). Baseline demographic, clinical, and cancer characteristics were extracted from the EHR and measured closest to the index date. Such factors included age, sex, race, ethnicity, and preferred language. Median household income was calculated with the patient's most recent mailing address documented in the EHR, geocoded via ArcGIS (Esri, Redlands, California),[41] and matched to census block-level income data. Disease-related covariates included tumor type, either solid or hematologic malignancy, advanced disease status, and Eastern Cooperative Oncology Group (ECOG) performance status. Advanced disease status was defined as a diagnosis of a metastatic solid tumor or a hematologic malignancy treated with transplant or cellular therapy. Patient age and length of time since establishing care within the University of Pennsylvania health system were calculated as the time from date of birth or first visit at the cancer center until patient identification as high-risk, respectively. Age, length of time since establishing care, and Charlson comorbidity index were categorized as quartiles on the basis of the distribution of data. Site of care was classified by whether the practice contained only tumor subspecialists, only general oncologists, or both. The calendar quarter when identified as high-risk was determined for each patient.

We summarized the distribution of patient characteristics, and $\chi^2$ tests assessed differences by first encounter type (telemedicine or in-person). Separate modified Poisson regressions estimated adjusted risk ratios (aRRs) for the associations between encounter type and documented advance care planning and unplanned hospitalization. To assess the potential for bias from misclassification of patients switching between telemedicine and in-person visits, we performed two sensitivity analyses. First, we censored follow-up time at the second encounter, and second, we restricted the cohort to those who did not change encounter type over the 3-month follow-up. We performed an additional sensitivity analysis excluding patients enrolled before July 2020 to account for bias from the rapid early adoption of telemedicine at our institution.

Advance care planning quality was assessed as an exploratory end point and defined via components of the Serious Illness Conversation Guide (SICG). The SICG is a structured conversation guide that can be incorporated into the EHR to promote accessible, comprehensive documentation of discussions about patients' goals and values.[42–44] On the basis of data showing that the use of the SICG led to more, earlier, and better SICs, we have adopted the SICG as our standard of care across oncology clinics at the University of Pennsylvania at our academic cancer center. The nine features from the SIC note template include the (1) prognosis communication, (2) prognostic understanding, (3) information preferences, (4) goals, (5) fears and worries, (6) strengths, (7) critical abilities, (8) tradeoffs, and (9) family involvement. These were coded as present or absent on the basis of a validated codebook used in a previous qualitative study of SICs[45] as well as to assess advance care planning within the University of Pennsylvania health system.[40] High-quality advance care planning was defined as including prognosis communication, patient prognostic understanding, and either patient goals or their fears and worries. These were based on recommendations for quality assessment of serious illness communication from national experts.[38] Low-quality advance care planning was defined as any documented advance care planning note that did not include prognosis communication, documentation of the patient's prognostic understanding, and either patient goals or their fears and worries. We summarized the distribution of high- and low-quality advance care planning, and $\chi^2$ tests assessed differences by first encounter type (telemedicine or in-person) as well as by telemedicine subtype (video-based, phone-based, or in-person). A multivariate adjusted analysis was not performed for this exploratory end point because of low numbers of cases of low-quality advance care planning.

## RESULTS

We identified 3178 high-risk patients with cancer during the study period, including 2430 patients (77%) seen in person and 748 patients (23%) seen by telemedicine at first encounter. The majority of telemedicine visits were video based ($n$ = 480; 64%). Patients seen in person were more likely to have advanced disease and receive care from a general oncologist compared to those seen by telemedicine (Table 1; 53% vs. 44%; 41% vs. 24%). Among patients using telemedicine, Black and lower income patients more frequently used phone than video (Table 1; 26% vs. 13%; 20% vs. 12%).

We found that 6% of patients ($n$ = 198) received advance care planning and 19% of patients ($n$ = 594) had an unplanned hospitalization during the 3-month follow-up period. There were no meaningful differences in the occurrence of advance care planning (6.8% vs. 6.0%; aRR, 1.25; 95% CI, 0.92–1.70) or unplanned hospitalization (20% vs. 18%; aRR, 1.09; 95% CI, 0.92–1.28) between patients receiving telemedicine and those receiving in-person visits (Table 2). However, telemedicine subtype (video- or phone-based) influenced advance care planning occurrence. Compared to in-person visits, advance care planning rates were comparable to phone-based telemedicine (phone-based, 5.6% vs. in-person, 6.0%; aRR, 0.99; 95% CI, 0.58–1.78) and were higher with video-based telemedicine (video-based, 7.5% vs. in-person, 6.0%; aRR, 1.48; 95% CI, 1.03–2.11). In contrast, unplanned hospitalization rates were not affected by telemedicine subtype. Most findings were robust to the multiple sensitivity analyses, although patients evaluated solely by phone during the 3-month follow-up had a higher likelihood of an unplanned hospitalization (32% vs. 21%; RR, 1.55; 95% CI, 1.16–2.08) (Tables S1–S3).

Information regarding ECOG performance status was missing for 1390 patients (43%) (Table S4). This covariate was therefore excluded from our final models because of the degree and concern for informative missingness. Complete case analyses (Table S5), including ECOG performance status, demonstrated a nonsignificant difference in the occurrence of advance care planning (telemedicine, 6.4% vs. in-person, 6.8%; aRR, 0.75; 95% CI, 0.48–1.18) and unplanned hospitalizations (telemedicine, 21.4% vs. in-person, 18.5%; aRR, 1.15; 95% CI, 0.93–1.42). However, the point estimate for comparisons of advance care planning differed between the primary (aRR, 1.25; 95% CI, 0.92–1.69) and complete case analyses (aRR, 0.75; 95% CI, 0.48–1.18).

**TABLE 1** Patient characteristics by first encounter type.

| | Total | | In-person | | Telemedicine | | $p^{a,b}$ | Video | | Phone | | $p^{a,c}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *N* = 3178 | | *n* = 2430 | | *n* = 748 | | | *n* = 480 | | *n* = 268 | | |
| Age, No. (%), years[d] | | | | | | | .576 | | | | | .191 |
| 18–57.9 | 822 | (25.87) | 632 | (26.01) | 190 | (25.40) | | 134 | (27.92) | 56 | (20.90) | |
| 58–66.9 | 881 | (27.72) | 659 | (27.12) | 222 | (29.68) | | 140 | (29.17) | 82 | (30.60) | |
| 67–74.9 | 787 | (24.76) | 610 | (25.10) | 177 | (23.66) | | 115 | (23.96) | 62 | (23.13) | |
| 75–100 | 688 | (21.65) | 529 | (21.77) | 159 | (21.26) | | 91 | (18.96) | 68 | (25.37) | |
| Time from date of first ACC visit to nudge, No. (%) | | | | | | | <.001 | | | | | <.001 |
| <1 month | 499 | (15.70) | 414 | (17.04) | 85 | (11.36) | | 62 | (12.92) | 23 | (8.58) | |
| 1–6 months | 1033 | (32.50) | 836 | (34.40) | 197 | (26.34) | | 135 | (28.13) | 62 | (23.13) | |
| 7 months–1 year | 327 | (10.29) | 246 | (10.12) | 81 | (10.83) | | 53 | (11.04) | 28 | (10.45) | |
| 1.1–3 years | 439 | (13.81) | 317 | (13.05) | 122 | (16.31) | | 73 | (15.21) | 49 | (18.28) | |
| 3+ years | 880 | (27.69) | 617 | (25.39) | 263 | (35.16) | | 157 | (32.71) | 106 | (39.55) | |
| Sex, No. (%) | | | | | | | .558 | | | | | .538 |
| Female | 1640 | (51.60) | 1261 | (51.89) | 379 | (50.67) | | 237 | (49.38) | 142 | (52.99) | |
| Male | 1538 | (48.40) | 1169 | (48.11) | 369 | (49.33) | | 243 | (50.63) | 126 | (47.01) | |
| Race/ethnicity, No. (%) | | | | | | | .119 | | | | | <.001 |
| White non-Hispanic | 2350 | (73.95) | 1784 | (73.42) | 566 | (75.67) | | 380 | (79.17) | 186 | (69.40) | |
| Black non-Hispanic | 558 | (17.56) | 427 | (17.57) | 131 | (17.51) | | 60 | (12.50) | 71 | (26.49) | |
| Asian non-Hispanic | 81 | (2.55) | 62 | (2.55) | 19 | (2.54) | | 15 | (3.13) | 4 | (1.49) | |
| Hispanic/Latino | 69 | (2.17) | 53 | (2.18) | 16 | (2.14) | | 11 | (2.29) | 5 | (1.87) | |
| Other | 120 | (3.78) | 104 | (4.28) | 16 | (2.14) | | 14 | (2.92) | 2 | (0.75) | |
| Preferred language, No. (%) | | | | | | | .352 | | | | | .404 |
| English | 3081 | (96.95) | 2352 | (96.79) | 729 | (97.46) | | 470 | (97.92) | 259 | (96.64) | |
| Non-English | 97 | (3.05) | 78 | (3.21) | 19 | (2.54) | | 10 | (2.08) | 9 | (3.36) | |
| Household income, No. (%)[e] | | | | | | | .456 | | | | | .012 |
| <$50,0000 | 515 | (16.21) | 403 | (16.58) | 112 | (14.97) | | 58 | (12.08) | 54 | (20.15) | |
| $50,000–$99,999 | 1496 | (47.07) | 1152 | (47.41) | 344 | (45.99) | | 221 | (46.04) | 123 | (45.90) | |
| $100,000+ | 1077 | (33.89) | 807 | (33.21) | 270 | (36.10) | | 190 | (39.58) | 80 | (29.85) | |
| Missing | 90 | (2.83) | 68 | (2.80) | 22 | (2.94) | | 11 | (2.29) | 11 | (4.10) | |
| ECOG performance status, No. (%) | | | | | | | .043 | | | | | .169 |
| 0 | 547 | (17.21) | 420 | (17.29) | 127 | (16.96) | | 85 | (17.71) | 42 | (15.61) | |
| 1 | 798 | (25.11) | 582 | (23.96) | 216 | (28.84) | | 142 | (29.58) | 74 | (27.51) | |
| 2 | 305 | (9.60) | 243 | (10.00) | 62 | (8.28) | | 40 | (8.33) | 22 | (8.18) | |
| 3 | 125 | (3.93) | 89 | (3.66) | 36 | (4.81) | | 21 | (4.38) | 15 | (5.58) | |
| 4 | 13 | (0.41) | 11 | (0.45) | 2 | (0.27) | | 2 | (0.42) | 0 | (0.00) | |
| Missing | 1390 | (43.74) | 1084 | (44.63) | 306 | (40.85) | | 190 | (39.58) | 116 | (43.12) | |
| Charlson comorbidity index quartiles, No. (%) | | | | | | | .345 | | | | | .517 |
| 1–2.9 | 1080 | (33.98) | 828 | (34.07) | 252 | (33.69) | | 164 | (34.17) | 88 | (32.84) | |
| 3–5.9 | 1095 | (34.46) | 846 | (34.81) | 249 | (33.29) | | 160 | (33.33) | 89 | (33.21) | |

(Continues)

**TABLE 1** (Continued)

| | Total | | In-person | | Telemedicine | | $p^{a,b}$ | Video | | Phone | | $p^{a,c}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6–6.9 | 431 | (13.56) | 337 | (13.87) | 94 | (12.57) | | 60 | (12.50) | 34 | (12.69) | |
| 7–13 | 569 | (17.90) | 417 | (17.16) | 152 | (20.32) | | 96 | (20.00) | 56 | (20.90) | |
| Missing | 3 | (0.09) | 2 | (0.08) | 1 | (0.13) | | 0 | (0.00) | 1 | (0.37) | |
| Tumor type, No. (%) | | | | | | | .021 | | | | | .055 |
| Solid | 2521 | (79.33) | 1950 | (80.25) | 571 | (76.34) | | 370 | (77.08) | 201 | (75.00) | |
| Liquid | 657 | (20.67) | 480 | (19.75) | 177 | (23.66) | | 110 | (22.92) | 67 | (25.00) | |
| Advanced disease, No. (%)[f] | | | | | | | <.001 | | | | | <.001 |
| No | 1572 | (49.47) | 1150 | (47.33) | 422 | (56.42) | | 251 | (52.29) | 171 | (63.81) | |
| Yes | 1606 | (50.53) | 1280 | (52.67) | 326 | (43.58) | | 229 | (47.71) | 97 | (36.19) | |
| Site of care, No. (%) | | | | | | | <.001 | | | | | <.001 |
| Subspecialty clinic | 1775 | (55.85) | 1250 | (51.44) | 525 | (70.19) | | 351 | (73.13) | 174 | (64.93) | |
| Mixed practice (specialists/ generalists) | 235 | (7.39) | 189 | (7.78) | 46 | (6.15) | | 34 | (7.08) | 12 | (4.48) | |
| General oncologists | 1168 | (36.75) | 991 | (40.78) | 177 | (23.66) | | 95 | (19.79) | 82 | (30.60) | |
| Calendar quarter, No. (%)[g] | | | | | | | <.001 | | | | | <.001 |
| 2 | 947 | (29.80) | 575 | (23.66) | 372 | (49.73) | | 209 | (43.54) | 163 | (60.82) | |
| 3 | 1037 | (32.63) | 851 | (35.02) | 186 | (24.87) | | 132 | (27.50) | 54 | (20.15) | |
| 4 | 1194 | (37.57) | 1004 | (41.32) | 190 | (25.40) | | 139 | (28.96) | 51 | (19.03) | |

Abbreviations: ACC, abramson cancer center; ECOG, Eastern Cooperative Oncology Group.

[a]*p* values are based on $\chi^2$ tests.

[b]Comparison of in-person visits and telemedicine.

[c]Comparison of in-person visits, video-based telemedicine, and phone-based telemedicine.

[d]Age when identified as high-risk.

[e]Block-level median household income with 2019 inflation-adjusted dollars.

[f]Diagnosis of a metastatic solid tumor or a hematologic malignancy treated with transplant or cellular therapy.

[g]Calendar quarter (2020) when the patient was identified as high risk.

Of the 199 advance care planning conversations, 83.4% ($n$ = 166) were of high quality. The occurrence of high-quality advance care planning was similar between telemedicine and in-person visits (Table S6; 78.9% vs. 85.0%; $p$ = .302). However, in regard to telemedicine subtype, patients evaluated by phone were less likely to have high-quality advance care planning (68.8%) than those with video-based evaluations (83.3%) or in-person visits (85.0%), although the differences did not achieve statistical significance (Table S6).

## DISCUSSION

In this large cohort, we demonstrated that care delivered by telemedicine, compared to in-person visits, produced comparable advance care planning rates without increasing hospitalizations. We propose several explanations for our findings. The ability to virtually meet patients and their family within the comfort of their home may facilitate advance care planning.[46,47] Likewise, telemedicine may increase access for vulnerable patients who are too frail to travel into the clinic.[48] Thus, telemedicine may help physicians overcome physical and logistical barriers to timely advance care planning. Overall, our findings suggest that vulnerable patients can be managed safely by telemedicine without negatively affecting key components of their care such as advance care planning and acute care utilization.

A common perception by clinicians is that telemedicine may result in missed opportunities to detect disease progression or treatment toxicity.[13,17,23,24] We found that unplanned hospitalizations were comparable between telemedicine and in-person visits (20% vs. 18%; aRR, 1.09; 95% CI, 0.92–1.28). This is consistent with reports by Hsiehchen et al., who found no association between telemedicine use and poorer patient outcomes, including oncology-related emergency department visits/hospitalizations, nonvisit telephone encounters, or time to treatment initiation.[49] Work by Dunwoodie and Tiwari similarly did not find a difference in emergency department utilization between telemedicine and never-telemedicine users over multiple time frames spanning 2018 to October 2020.[50] However, compared to those seen in the clinic, patients evaluated solely by phone during the 3-month follow-up had a higher likelihood of an unplanned hospitalization (32% vs. 21%; aRR, 1.55; 95% CI,

**TABLE 2** Comparisons of outcomes in palliative oncology care between telemedicine and in-person visits.

| | Events, No. | Risk[e] | Crude RR (95% CI) | Adjusted RR (95% CI) |
|---|---|---|---|---|
| Advance care planning | | | | |
| Telemedicine[a] | 51 | 51/748 (6.8%) | 1.13 (0.83–1.53) | 1.25 (0.92–1.69) |
| In-person[a] | 147 | 147/2430 (6.0%) | 1 (reference) | 1 (reference) |
| Video-based telemedicine[b] | 36 | 36/480 (7.5%) | 1.24 (0.87–1.76) | 1.48 (1.03–2.11) |
| Phone-based telemedicine[b] | 15 | 15/268 (5.6%) | 0.93 (0.55–1.55) | 0.99 (0.58–1.70) |
| In-person[b] | 147 | 147/2430 (6.0%) | 1 (reference) | 1 (reference) |
| Unplanned hospitalizations | | | | |
| Telemedicine[c] | 150 | 150/748 (20.0%) | 1.10 (0.93–1.30) | 1.09 (0.92–1.28) |
| In-person[c] | 444 | 444/2430 (18.3%) | 1 (reference) | 1 (reference) |
| Video-based telemedicine[d] | 99 | 99/480 (20.6%) | 1.13 (0.93–1.37) | 1.14 (0.93–1.39) |
| Phone-based telemedicine[d] | 51 | 51/268 (19.0%) | 1.04 (0.80–1.35) | 1.06 (0.81–1.38) |
| In-person[d] | 444 | 444/2430 (18.3%) | 1 (reference) | 1 (reference) |

Abbreviations: ACC, abramson cancer center; RR, risk ratio.

[a]Adjusted for length of time at the ACC, advanced disease status, site of care, race/ethnicity, Charlson comorbidity index, and solid versus liquid malignancy.

[b]Adjusted for length of time at the ACC, advanced disease status, site of care, race/ethnicity, Charlson comorbidity index, solid versus liquid malignancy, and median household income.

[c]Adjusted for length of time at the ACC, site of care, and Charlson comorbidity index.

[d]Adjusted for length of time at the ACC, race/ethnicity, site of care, and median household income.

[e]Outcome occurrence/ # patients.

1.16–2.08), which implies the importance of intermittent visual assessments of the patient.

Our work has several limitations. First, we defined our exposure by the first encounter type (telemedicine or in-person visit), which could have resulted in misclassification bias. However, our results were similar when we limited the cohort to those who did not change encounter type and when we censored patients at the second encounter. Second, the study cohort was limited to a single academic institution, and thus our findings may not be generalizable to other centers. Third, ECOG performance status was missing for approximately 40% of our patient cohort and cannot be excluded as a potential confounder. Fourth, we could not control for dynamic factors that may have influenced a patient's decision to participate in a telemedicine or in-person visit such as same-day symptoms and performance status. Fifth, our study represents the first year of the coronavirus disease 2019 pandemic, a time of transition in multiple aspects of clinical care. Although we could not control for all changes associated with the pandemic, analyses restricted to the time after telemedicine use had stabilized produced comparable results to our primary analyses. Finally, because this is a retrospective cohort study with the University of Pennsylvania EHR, we were unable to capture hospitalizations that occurred at outside facilities, which could alter our finding of no increased association between telemedicine and unplanned hospitalizations if hospitalizations at outside hospitals are more or less common for patients who use telemedicine.

Although our work reassures clinicians engaging with telemedicine in the palliative care setting, the best implementation strategies remain unclear. For example, the optimum balance between telemedicine and in-person visits remains an open-ended question. Currently, patients switch between telemedicine and in-person visits; analyses clarifying the ideal cadence of telemedicine versus in-person care among different patient cohorts are needed. Additionally, the benefits of telemedicine depend on patient and clinician access to, and comfort with, digital technology and broadband internet.[51,52] We found that video-based visits were associated with higher rates of advance care planning in comparison to in-person visits, whereas phone-based encounters performed comparably to in-person care. Furthermore, we found that phone-based encounters were more frequently associated with low-quality advance care planning in comparison to video-based and in-person encounters. As such, although this work is exploratory, it suggests the importance of video-enabled telemedicine care. However, prior work supports our findings of barriers in access to video-enabled telemedicine among racial and ethnic minorities[32–35,53] and those with lower income.[35,54–56] Successful implementation of telemedicine in this setting will require efforts to achieve equitable access to high-quality video-based telemedicine platforms. Also, although it is reassuring that telemedicine does not impede advance care planning, the rates of these critical conversations remain unacceptably low (~6%). This low rate of advance care planning may reflect documentation in other parts of the EHR; however, our definition of advance care planning occurrence mimicked that used to routinely evaluate clinicians on their advance care planning performance and has been successfully used in prior studies using the University of Pennsylvania EHR.[37]

With that said, work will be needed to understand how the medium by which advance care planning is done (telemedicine vs. in-person) influences patient outcomes such that timely hospice enrollment and the use of chemotherapy and acute care occur during the last months of life. This can be achieved with thoughtfully designed prospective cohort studies and pilot studies measuring telemedicine's effectiveness at targeting these end points. Also, to use telemedicine as a tool to increase access to these critical conversations, a deeper understanding of the barriers and facilitators of its use among high-risk patients is required. This can be achieved via mixed methods studies designed to evaluate potential workflows for increasing advance care planning access via telemedicine combined with iterative feedback from key stakeholders, including high-risk patients.[57]

In summary, we did not identify a detrimental association between telemedicine and advance care planning or unplanned hospitalizations among palliative patients with cancer who received care via telemedicine as compared to in-person visits. Further work is needed to optimize telemedicine delivery in palliative oncology and identify barriers to high-quality equitable implementation.

## AUTHOR CONTRIBUTIONS

**Erin M. Bange:** Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, software, writing original draft, and validation. **Yimei Li:** Formal analysis, investigation, methodology, supervision, writing-review and editing, and validation. **Pallavi Kumar:** Conceptualization, methodology, supervision, writing-review and editing, and validation. **Abigail Doucette:** Data curation, resources, and software. **Peter Gabriel:** Data curation, resources, and software. **Ravi Parikh:** Methodology and writing-review and editing. **Eric H. Li:** Methodology. **Ronac Mamtani:** Conceptualization, formal analysis, investigation, methodology, project administration, supervision, writing-review and editing, and validation. **Kelly D. Getz:** Conceptualization, formal analysis, investigation, methodology, project administration, supervision, writing-review and editing, and validation.

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## CONFLICT OF INTEREST STATEMENT

Erin M. Bange reports serving as a consultant for Flatiron Health. Ravi Parikh reports serving as a consultant for Thyme Care, the Coalition to Transform Advanced Care, the Humana Foundation, Genetic Chemistry, GNS Healthcare, ConcertAI, CreditSuisse, G1 Therapeutics, Biofourmis, Merck, Onc.ai, and Medscape and receiving grants from the Prostate Cancer Foundation and Mendel.ai. Ronac Mamtani reports serving as a consultant for Seagen, Astellas, and Bristol-Myers Squibb; receiving personal fees from Flatiron Health, Astellas, Seattle Genetics, and Bristol-Myers Squibb; and receiving a research grant from Merck outside the submitted work. Kelly D. Getz reports receiving grants from GlaxoSmithKline. The other authors declare no conflicts of interest.

## DATA AVAILABILITY STATEMENT

The data underlying this article cannot be shared in order to protect the privacy of the individuals who participated in the study. Deidentified data can be requested and will be distributed with the permission of the University of Pennsylvania Institutional Review Board.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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