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Preventive health service use among survivors of adolescent and young adult cancer

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ABSTRACT

Preventive health screenings are essential for survivors of adolescent and young adult (AYA) cancer survivors, who are at greater risk for non-cancer related death compared to individuals without a history of cancer. However, little research exists examining their use of screening services. In order to identify potential areas for targeted improvements in AYA survivorship care, we examined adherence to United States Preventive Services Task Force (USPSTF) screening recommendations among members of Kaiser Permanente Southern California. The study population included individuals diagnosed with cancer between ages 15–39 from 2000 to 2012 who survived at least two years post-diagnosis (n = 6779) and a matched cohort of non-cancer comparisons (n = 25640). To assess adherence to screening services, we calculated a Prevention Index (PI, proportion of person-time covered by receipt of recommended clinical preventive services relative to the time eligible) for every individual and the distributions for each service. We also evaluated predictors for adherence using logistic regression. Adherence was significantly (p-value < 0.05) higher among survivors than non-cancer subjects for screenings for dyslipidemia (71.16% and 65.94, respectively), hypertension (97.43% and 89.11%), cervical cancer (87.36% and 84.45%), colorectal cancer (83.23% and 58.27%), and influenza vaccination (36.79% and 33.21%). The logistic regression showed that survivors were significantly more likely to adhere to guidelines compared to non-cancer peers for all screenings except breast cancer, with the greatest difference found for colorectal cancer (odds ratio: 5.04, p-value: <0.01). While AYA survivors appear to use preventive screenings more than comparisons, there is room for improvement for certain services, most notably for influenza vaccination.

1. Introduction

For the growing number of adolescents and young adults (AYA) diagnosed with cancer, the goal is not just survival, but also many healthy years of life. Although important for the general population, preventive health screenings are especially vital for AYA cancer survivors, who are at greater risk of non-cancer related death compared to individuals without a history of cancer (Anderson et al., 2019). There is a dearth of research exploring the AYA survivorship care experience, including their long-term preventive health behaviors.

AYA cancer survivors, defined as individuals diagnosed between ages 15–39 per the National Cancer Institute (Snyder et al., 2009), appear more likely to develop specific conditions, including cardiovascular disease and second malignancies, and to die as a result (Chao et al., 2016; Keegan et al., 2018). They also appear to engage in unhealthy behaviors more than non-cancer comparisons across a variety of

Abbreviations: AYA, Adolescent and young adult; USPSTF, United States Preventive Service Task Force; KPSC, Kaiser Permanente Southern California; SEER, Surveillance, Epidemiology, and End Results; PI, Prevention Index.

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domains, with higher rates of smoking, obesity, and hypertension (Tai et al., 2012). With the exception of those identified as high-risk for specific late effects, cancer survivors are recommended to follow the same guidelines for preventive screenings as the general population.

Although data on survivors of AYA cancer are lacking, studies have reported preventive service utilization among survivors of adult-onset cancer as well as survivors of childhood cancer. Among survivors of adult-onset cancer, findings from existing studies of preventive health care services have been mixed, reporting both higher and lower rates than non-cancer comparisons, depending on the screening and study population. Studies have reported that breast (Snyder et al., 2009a, 2009b) and colorectal cancer survivors (Snyder et al., 2013; Earle and Neville, 2004) are less likely to receive preventive care compared to cancer-free controls. However, survivors appear to be more likely to receive recommended screenings for additional sites of primary cancer (Mayer et al., 2007; Uhlig et al., 2017; Corkum et al., 2013). Among adult survivors of childhood cancer, previous research has found sub-optimal adherence to screening recommendations from the United States Preventive Service Task Force (USPSTF) (Yeazel et al., 2004). Yet, in a study of female survivors diagnosed with cancer prior to age 25 years, they were more likely than non-cancer comparisons to receive screening for cervical cancer (Tseng et al., 2017).

The aim of this study was to compare the preventive health screening utilizations of AYA cancer survivors and a matched cohort of non-cancer survivors to gain insight into potential gaps in survivorship care. A better understanding about preventive service use in this population will clarify areas which need improvement and help in the development of targeted strategies to ensure more quality years of life among young survivors. Further, existing survey studies on AYA cancer survivors have highlighted the challenge of insurance instability and cost as barriers for health services use (Kirchhoff et al., 2012; Kaul et al., 2017). Our study based on members of the same integrated health care system with relatively equal access will help answer whether AYA cancer survivors will utilize preventive services if access and cost barriers are removed.

2. Methods

2.1. Study setting and population

This study was conducted at Kaiser Permanente Southern California (KPSC), an integrated health care delivery system serving over 4.5 million racially and socio-economically diverse members throughout the region (Koebnick et al., 2012). We examined adherence to USPSTF screening recommendations for cancer survivors and a matched cohort of non-cancer comparisons for screening for dyslipidemia, hypertension, breast cancer, cervical cancer, and colorectal cancer, and influenza vaccination. This analysis was approved by KPSC's Institutional Review Board (#11016), and a waiver of informed consent was granted. KPSC members diagnosed with cancer between ages 15–39 from 2000 to 2012 who survived at least two years post-diagnosis were identified using KPSC's Surveillance, Epidemiology, and End Results (SEER)-affiliated cancer registry. From this overall cohort, individual subjects eligible to receive each of the screening or vaccination service of interest were identified. The full inclusion and exclusion criteria for each screening and vaccination service are provided in Table 1. In brief, USPSTF screening recommendations for each service we examined is as follows: 1) dyslipidemia screening recommended every 5 years for males age 35–65 years and females age 45–65 years; 2) hypertension screening recommended every 2 years for males and females age $\geq$ 18 years; 3) influenza vaccination recommended yearly for both sexes of all ages; 4) breast cancer screening recommended every 2 years for females age 50–69 years; 5) cervical cancer screening recommended for females age 21–65 years; and 6) colorectal cancer screening recommended for males and females age 50–80 years.

For breast, cervical, and colorectal cancer screenings, survivors considered high-risk for late effects from therapeutic exposures per the

Table 1
Selected preventive services recommended by United States Preventive Service Task Force for average-risk persons.

Screening type	Eligibility criteria		Screening method, interval	Diagnosis and procedure criteria for excluding person-time from analyses
	Sex	Age		
Dyslipidemia	Male and female	Male: 35–65 years Female: 45–65 years	Lipid panel, every 5 years	**Diabetes mellitus (based on POINT definition)** ICD diagnosis code *or* HgbA1c > 7.5 *or* Prescribed medication **Cardiovascular disease** 1 inpatient diagnosis *or* ≥2 outpatient diagnoses on separate days within 12 months **Dyslipidemia** 1 inpatient diagnosis or ≥ 2 outpatient diagnoses *or* ≥1 outpatient diagnosis + ≥1 prescribed medication *or* ≥2 prescribed medication on separate days within 12 months
Hypertension	Male and female	≥18 years	Blood pressure, every 2 years	**Hypertension** 1 inpatient diagnosis *or* ≥2 outpatient diagnosis *or* ≥1 outpatient diagnosis + ≥1 prescribed medication on separate days within 12 months
Influenza vaccination	Male and female	All ages	Every year	**None**
Breast cancer	Female	50–69 years	Mammogram, 2 years	**Breast cancer Bilateral mastectomy**
Cervical cancer	Female	21–29 years	Pap, every 3 years	**Cervical cancer**
		30–65 years	HPV co-testing, every 5 years	**Hysterectomy**
Colorectal cancer	Male and female	50–80 years	Fecal occult blood test, every year	**Colorectal cancer, polyposis, ulcerative colitis, or Crohn's disease** 1 inpatient diagnosis *or* ≥2 outpatient diagnoses on separate days within 12 months
			Sigmoidoscopy, every 5 years	
			Colonoscopy, every 10 years	

National Comprehensive Cancer Network's Clinical Practice Guidelines for Adolescent and Young Adult Oncology (Clinical Practice Guidelines in Oncology; Koebnick et al., 2012) were excluded from the analysis, as screening recommendations differ for these groups. Individuals whose primary cancer site matched the screening service were also excluded from the specific screening service assessment (e.g., breast cancer survivors were not included in the breast cancer screening service analysis) since they should be on a guideline-recommended cancer surveillance schedule.

Eligible survivors were followed until the end of 2016, death, termination of KP membership, diagnosis of second malignancy, or diagnosis of the disease for which screening was conducted (e.g., breast cancer for mammogram screening). Laboratory tests, prescription medications, a diagnosis, or a procedure which would make the patient ineligible for the specific screening service (e.g., hysterectomy for cervical cancer screening) were used to indicate the conditions to truncate person-time.

The non-cancer comparison subjects were matched 4:1 to the cancer survivors by age (yearly), sex, zip code (at index date), and index calendar year with a greedy algorithm. We used records from KPSC's cancer registry to exclude members with a history of cancer from selection into the comparison cohort.

2.2. *Data collection*

All data were collected from KPSC's electronic health records and cancer registry. Age at cancer diagnosis, cancer type and stage, and race/ethnicity were obtained from membership files and the cancer registry. Screening service use was identified from laboratory (lipid panel, Pap smear/HPV co-testing, fecal occult blood test), vital sign (blood pressure), immunization records (influenza vaccination), and radiology utilization (mammogram, sigmoidoscopy, and colonoscopy) data. Unique member identifiers were used to link a patient across multiple databases.

2.3. *Prevention Index*

We calculated a Prevention Index (PI) for each individual to evaluate adherence to a given preventive service. The PI is the proportion of person-time covered by receipt of a recommended clinical preventive service relative to the total person-time during which a subject is eligible to receive such service (Vogt et al., 2004, 2007). For example, for hypertension screening recommended at every 2 years, the 2 years after the receipt of a blood pressure screening by an eligible individual will be considered the covered person-time for that individual. On the other hand, person-time before the receipt of the screening service and beyond 2 years after the receipt of the screening service will be considered uncovered person-time for that individual until the receipt of the next screening service. The total eligible person-time for each preventive service for an individual during the study period was thus defined into protions of covered vs. uncovered person time, and the PI was the protion of the covered person-time out of total eligible person-time. As the PI is a person-time based appraoch and does not require the unrealistic assumption of a closed cohort, it is particularly suitable for real-world settings where censoring can occur.

2.4. *Statistical analysis*

We first calculated the distributions of demographic and clinical characteristics of survivors and the non-cancer comparison subjects included in each screening and vaccination service examination. We also evaluated healthcare utilization among the study population for the year prior to the date a subject became eligible for a particular preventive health service (e.g., age 50 for breast cancer screening). T-tests were used to compare the means of the PIs between cancer survivors and the non-cancer group. We also dichotomized the PI to evaluate differences in adherence to preventative screening recommendations between the two groups using logistic regression, adjusting for age group (age by decades: 15–19 years, 20–29 years, 30–39 years), sex (if applicable), race/ethnicity (Asian/Pacific Islander, Black, Hispanic, Other/Unknown, White), and Charlson comorbidity index (Quan et al., 2005; Deyo et al., 1992) (unweighted, cancer history not counted). The cut-off value for the dichotomization was set to be 75% for all preventive services except for influenza vaccination, which was set at 50%. These cut-offs were chosen based on three considerations: to allow proper statistical power of the analyses (the empirical distribution of the PI score was examined), to ensure the outcomes were clinically meaningful, and to maximize consistency of the cut-off between services when possible. The Bayesian Improved Surname Geocoding imputation method was used to impute for the missing race/ethnicity information (3–12% missing in non-cancer comparison subjects across preventive services) (Derose et al., 2013). All analyses in this study were carried out using SAS Version 9.3; Cary, North Carolina, USA.

3. Results

3.1. *General characteristics*

General characteristics for AYA cancer survivors and the non-cancer group are presented in Table 2. The cancer survivors and non-cancer subjects included for evaluation of each screening service were comparable in their demographic characteristics. Compared to other screening services, the greatest number of survivors were eligible to receive influenza vaccination (n = 6779), as it is suggested for the broadest range of individuals (both sexes of all ages). The fewest number of AYA survivors were eligible for breast cancer screening (n = 191), which is recommended for females age ≥ 50 years. The median age of cancer diagnosis ranged from 33 years (hypertension screening and influenza vaccination) to 38 years (breast cancer and colorectal cancer screening). Stage I cancer was most frequently diagnosed across all screening services, ranging from 48.8% to 61.8% for cervical cancer screening and breast cancer screening, respectively. We also found that cancer survivors had a substantially higher number of healthcare encounters than the matched comparisons in the year prior to the date eligible for a screening service [mean 13.3 (SD 13.9) vs. mean: 4.8 (SD 6.8)]

3.2. *Dyslipidemia*

Among 1900 AYA cancer survivors eligible for lipid screening, 40.1% were female and 59.9% were male, and approximately half (51.9%) were diagnosed with Stage I cancer. The mean PI was 71.2% compared to 65.9% of the non-cancer cohort (Table 3). The *t*-test to compare group differences indicated a significant difference between these groups ($p < 0.01$). Using a PI cut-off value of 75% (i.e., the percent of person-time in compliance with the recommendation during the study period), the adjusted OR (Table 4) suggested survivors were more likely to comply with lipid screening recommendations than the non-cancer comparisons (OR: 1.31, 95% CI: 1.18–1.47, p-value: <0.01).

3.3. *Hypertension*

Hypertension screening was recommended for 4894 cancer survivors. Among those, 65.9% were females. The mean PI was significantly higher for cancer survivors than non-cancer comparisons (97.4% vs. 89.1%, $p < 0.01$) (Table 3). Using a PI cut-off point of 75%, the logistic regression indicated a substantially higher likelihood of cancer survivors receiving hypertension screening compared to the non-cancer group (OR: 4.24, 95% CI: 3.62–4.98, p-value: <0.01) (Table 4).

3.4. *Influenza vaccine*

For the 6779 survivors, the mean PI was 36.8%, which were significantly higher than the non-cancer group: 26.8% (p-value: <0.01) (Table 3). Based on the distribution of the PI, we used a PI cut-off point of 50% in the logistic regression, and found cancer survivors were 1.5-fold more likely to receive influenza vaccination than the comparison group (OR: 1.50, 95% CI: 1.41–1.60, p-value: <0.01) (Table 4).

Table 2
General characteristics of the study population (initial cancer diagnosed 2000–2012) by preventive health service, Kaiser Permanente Southern California.

	Dyslipidemia screening[1]			Hypertension screening[2]			Influenza Vaccination[3]		
	Cancer survivors	Non-cancer group	Total	Cancer survivors	Non-cancer group	Total	Cancer survivors	Non-cancer group	Total
	(n = 1900)	(n = 8102)	(n = 10002)	(n = 4894)	(n = 19450)	(n = 24344)	(n = 6779)	(n = 25,640)	(n = 32419)
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Follow-up period (years)	4.00 (3.22)	4.00 (3.29)	4.00 (3.27)	4.30 (2.61)	4.4 (2.63)	4.4 (2.63)	5.2 (3.88)	5.2 (3.88)	5.2 (3.88)
Age[7]	35.20 (3.47)	35.20 (3.48)	35.2 (3.48)	31.1 (6.54)	31.3 (6.44)	31.2 (6.46)	31.3 (6.53)	31.3 (6.54)	31.3 (6.54)
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Age group[7]									
15–19 years	–[8] (0.05%)	–[8] (0.02%)	–[8] (0.03%)	387 (7.91%)	1402 (7.21%)	1789 (7.35%)	521 (7.69%)	1994 (7.78%)	2515 (7.76%)
20–29 years	137 (7.21%)	568 (7.01%)	705 (7.05%)	1294 (26.44%)	5027 (25.85%)	6321 (25.97%)	1707 (25.18%)	6451 (25.16%)	8158 (25.16%)
30–39 years	1762 (92.74%)	7532 (92.96%)	9294 (92.92%)	3213 (65.65%)	13021 (66.95%)	16234 (66.69%)	4551 (67.13%)	17195 (67.06%)	21746 (67.08%)
Sex									
Female	762 (40.11%)	3311 (40.87%)	4073 (40.72%)	3227 (65.94%)	12852 (66.08%)	16079 (66.05%)	4427 (65.30%)	16729 (65.25%)	21156 (65.26%)
Male	1138 (59.89%)	4791 (59.13%)	5929 (59.28%)	1667 (34.06%)	6598 (33.92%)	8265 (33.95%)	2352 (34.70%)	8911 (34.75%)	11263 (34.74%)
Race/ethnicity									
Asian/Pacific Islander	178 (9.37%)	829 (10.23%)	1007 (10.07%)	516 (10.54%)	2125 (10.93%)	2641 (10.85%)	696 (10.27%)	2575 (10.04%)	3271 (10.09%)
Black	125 (6.58%)	717 (8.85%)	842 (8.42%)	307 (6.27%)	1615 (8.30%)	1922 (7.90%)	535 (7.89%)	2311 (9.01%)	2846 (8.78%)
Hispanic	670 (35.26%)	2917 (36%)	3587 (35.86%)	2021 (41.30%)	8154 (41.92%)	10175 (41.8%)	2698 (39.8%)	10074 (39.29%)	12772 (39.40%)
Other/Unknown	–[8] (0.26%)	940 (11.6%)	945 (9.45%)	–[8] (0.37%)	1646 (8.46%)	1664 (6.84%)	31 (0.46%)	3117 (12.16%)	3148 (9.71%)
White	922 (48.53%)	2699 (33.31%)	3621 (36.20%)	2032 (41.52%)	5910 (30.39%)	7942 (32.62%)	2819 (41.58%)	7563 (29.5%)	10382 (32.02%)
Cancer type group									
Acute lymphocytic leukemia	15 (0.79%)			49 (1.00%)			77 (1.14%)		
Acute myeloid leukemia	34 (1.79%)			94 (1.92%)			126 (1.86%)		
Bone	–[8] (0.32%)			45 (0.92%)			69 (1.02%)		
Brain	59 (3.11%)			190 (3.88%)			268 (3.95%)		
Breast	259 (13.63%)			766 (15.65%)			1067 (15.74%)		
Female genitourinary	88 (4.63%)			354 (7.23%)			518 (7.64%)		
Gastrointestinal	156 (8.21%)			255 (5.21%)			373 (5.5%)		
Hodgkin lymphoma	76 (4.00%)			301 (6.15%)			394 (5.81%)		
Lung	–[8] (0.58%)			51 (1.04%)			69 (1.02%)		
Multiple myeloma	–[8] (0.74%)			–[8] (0.29%)			25 (0.37%)		
Male genitourinary	287 (15.11%)			456 (9.32%)			601 (8.87%)		
Melanoma	248 (13.05%)			487 (9.95%)			663 (9.78%)		
Non-Hodgkin lymphoma	101 (5.32%)			245 (5.01%)			341 (5.03%)		
Oropharynx	62 (3.26%)			114 (2.33%)			158 (2.33%)		
Other	105 (5.53%)			225 (4.6%)			330 (4.87%)		
Ovary	28 (1.47%)			193 (3.94%)			278 (4.10%)		
Renal	82 (4.32%)			133 (2.72%)			197 (2.91%)		
Sarcoma	35 (1.84%)			98 (2.00%)			143 (2.11%)		
Thyroid	234 (12.32%)			824 (16.84%)			1082 (15.96%)		
TNM Stage									
Not Applicable	245 (12.89%)			646 (13.2%)			925 (13.65%)		
Stage I	986 (51.89%)			2478 (50.63%)			3319 (48.96%)		
Stage II	342 (18%)			916 (18.72%)			1315 (19.4%)		
Stage III	179 (9.42%)			448 (9.15%)			644 (9.5%)		
Stage IV	85 (4.47%)			204 (4.17%)			296 (4.37%)		
Unknown	63 (3.32%)			202 (4.13%)			280 (4.13%)		

	Breast cancer screening[4]			Cervical cancer screening[5]			Colorectal cancer screening[6]		
	Cancer survivors	Non-cancer group	Total	Cancer survivors	Non-cancer group	Total	Cancer survivors	Non-cancer group	Total
	(n = 191)	(n = 1308)	(n = 1499)	(n = 3697)	(n = 16313)	(n = 20010)	(n = 411)	(n = 1791)	(n = 2202)
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Follow-up period (years)	2.4 (1.63)	2.5 (1.63)	2.5 (1.63)	4.9 (3.74)	5.1 (3.84)	5.1 (3.82)	2.3 (1.62)	2.4 (1.63)	2.4 (1.62)
Age[7]	37.5 (1.48)	37.6 (1.45)	37.6 (1.46)	31.7 (6.23)	32.1 (5.98)	32.0 (6.03)	37.5 (1.51)	37.5 (1.48)	37.5 (1.48)
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**

(*continued on next page*)

Table 2 (*continued*)

	Breast cancer screening[4]			Cervical cancer screening[5]			Colorectal cancer screening[6]		
	Cancer survivors	Non-cancer group	Total	Cancer survivors	Non-cancer group	Total	Cancer survivors	Non-cancer group	Total
Age group[7]									
15–19 years				219 (5.92%)	795 (4.87%)	1014 (5.07%)			
20–29 years				924 (24.99%)	3829 (23.47%)	4753 (23.75%)			
30–39 years	191 (100%)	1308 (100%)	1499 (100%)	2554 (69.08%)	11689 (71.65%)	14243 (71.18%)	411 (100%)	1791 (100%)	2202 (100%)
Sex									
Female	191 (100%)	1308 (100%)	1499 (100%)	3697 (100%)	16313 (100%)	20010 (100%)	296 (72.02%)	1309 (73.09%)	1605 (72.89%)
Male							115 (27.98%)	482 (26.91%)	597 (27.11%)
Race/ethnicity									
Asian/Pacific Islander	32 (16.75%)	145 (11.09%)	177 (11.81%)	446 (12.06%)	1816 (11.13%)	2262 (11.3%)	46 (11.19%)	190 (10.61%)	236 (10.72%)
Black	-[8] (7.85%)	152 (11.62%)	167 (11.14%)	360 (9.74%)	1670 (10.24%)	2030 (10.14%)	39 (9.49%)	197 (11%)	236 (10.72%)
Hispanic	66 (34.55%)	492 (37.61%)	558 (37.22%)	1420 (38.41%)	6670 (40.89%)	8090 (40.43%)	144 (35.04%)	638 (35.62%)	782 (35.51%)
Other/Unknown	-[8] (0%)	33 (2.52%)	33 (2.2%)	-[8] (0.38%)	1460 (8.95%)	1474 (7.37%)	-[8] (0%)	77 (4.3%)	77 (3.5%)
White	78 (40.84%)	486 (37.16%)	564 (37.63%)	1457 (39.41%)	4697 (28.79%)	6154 (30.75%)	182 (44.28%)	689 (38.47%)	871 (39.55%)
Cancer type group									
Acute lymphocytic leukemia	–[8] (1.05%)			–[8] (0.54%)			–[8] (0.97%)		
Acute myeloid leukemia	–[8] (0.52%)			55 (1.49%)			–[8] (0.73%)		
Bone				–[8] (0.73%)			–[8] (0.24%)		
Brain	–[8] (4.19%)			130 (3.52%)			–[8] (2.92%)		
Breast				999 (27.02%)			116 (28.22%)		
Female genitourinary	40 (20.94%)			44 (1.19%)			39 (9.49%)		
Gastrointestinal	–[8] (6.28%)			158 (4.27%)			–[8] (1.46%)		
Hodgkin lymphoma	–[8] (2.62%)			194 (5.25%)			–[8] (2.43%)		
Lung				41 (1.11%)					
Multiple myeloma				–[8] (0.32%)					
Male genitourinary							–[8] (6.57%)		
Melanoma	34 (17.8%)			412 (11.14%)			57 (13.87%)		
Non–Hodgkin lymphoma	–[8] (3.66%)			156 (4.22%)			–[8] (5.6%)		
Oropharynx	–[8] (2.62%)			67 (1.81%)			–[8] (2.19%)		
Other	–[8] (3.66%)			150 (4.06%)			–[8] (3.65%)		
Ovary	–[8] (4.71%)			185 (5%)			–[8] (2.19%)		
Renal	–[8] (3.66%)			78 (2.11%)			–[8] (2.92%)		
Sarcoma	–[8] (1.05%)			78 (2.11%)			–[8] (1.22%)		
Thyroid	47 (24.61%)			891 (24.1%)			63 (15.33%)		
TNM Stage									
Not Applicable	–[8] (9.42%)			400 (10.82%)			33 (8.03%)		
Stage I	118 (61.78%)			1803 (48.77%)			208 (50.61%)		
Stage II	–[8] (13.09%)			877 (23.72%)			104 (25.3%)		
Stage III	–[8] (6.81%)			319 (8.63%)			37 (9%)		
Stage IV	–[8] (3.14%)			137 (3.71%)			–[8] (2.92%)		
Unknown	–[8] (5.76%)			161 (4.35%)			–[8] (4.14%)		

SD: standard deviation.
[4] Recommended for females age 50–69 years.
[5] Recommended for females age 21–65 years.
[6] Recommended for individuals age 50–80 years.
[1] Recommended for males age 35–65 years, females age 45–65 years.
[2] Recommended for age $\geq$ 18 years; individuals who ended study prior to 2009 excluded.
[3] Recommended for all ages.
[7] For cancer survivors, age and age group indicate age at time of cancer diagnosis.
[8] For N $<$ 30, cell size is masked for protecting patient confidentiality; only the percentage is shown.

Table 3
Prevention index for selected health services.

	N	Lower Quartile %	Median %	Upper Quartile %	Mean %	Standard Deviation %	P-value[1]
Dyslipidemia screening							
Overall	**10,002**	**23.25**	**96.07**	**100.00**	**66.93**	**41.26**	
Cancer survivors	1900	41.86	100.00	100.00	71.16	39.33	<0.01
Non-cancer group	8102	18.78	94.07	100.00	65.94	41.64	
Hypertension screening							
Overall	**24,344**	**97.60**	**100.00**	**100.00**	**90.78**	**22.65**	
Cancer survivors	4894	100.00	100.00	100.00	97.43	11.43	<0.01
Non-cancer group	19,450	93.63	100.00	100.00	89.11	24.40	
Influenza vaccination							
Overall	**32,419**	**0.00**	**13.61**	**53.35**	**28.91**	**34.17**	
Cancer survivors	6779	0.00	27.59	69.45	36.79	36.52	<0.01
Non-cancer group	25,640	0.00	9.92	48.79	26.83	33.21	
Breast cancer screening							
Overall	**1499**	**73.31**	**97.21**	**100.00**	**78.91**	**33.30**	
Cancer survivors	191	76.12	97.49	100.00	79.66	33.45	0.07
Non-cancer group	1308	72.43	97.21	100.00	78.80	33.28	
Cervical cancer screening							
Overall	**20,010**	**86.07**	**100.00**	**100.00**	**84.99**	**28.71**	
Cancer survivors	3697	90.05	100.00	100.00	87.36	26.27	<0.01
Non-cancer group	16,313	85.10	100.00	100.00	84.45	29.21	
Colorectal cancer screening							
Overall	**2202**	**30.75**	**79.05**	**95.94**	**62.93**	**37.57**	
Cancer survivors	411	83.11	97.23	100.00	83.23	30.07	<0.01
Non-cancer group	1791	20.76	71.76	91.16	58.27	37.58	

[1] Determined from *t*-test to compare means.

Table 4
Odds ratios (OR) for preventive service adherence for AYA cancer survivor status.

		Crude model			Adjusted model[2]		
Preventive service	Cut-off for PI	OR[1]	95% CI	P-value	OR	95% CI	P-value
Dyslipidemia screening	75%	1.29	(1.16–1.43)	<0.01	1.31	(1.18–1.47)	<0.01
Hypertension screening	75%	4.60	(3.94–5.38)	<0.01	4.28	(3.65–5.02)	<0.01
Influenza vaccination	50%	1.72	(1.62–1.82)	<0.01	1.51	(1.42–1.61)	<0.01
Breast cancer screening	75%	1.12	(0.79–1.6)	0.53	1.13	(0.79–1.61)	0.50
Cervical cancer screening	75%	1.28	(1.16–1.41)	<0.01	1.32	(1.19–1.46)	<0.01
Colorectal cancer screening	75%	5.04	(3.86–6.59)	<0.01	5.01	(3.82–6.55)	<0.01

OR: Odds ratio; PI: Prevention Index; **95% CI**: 95% confidence interval.[1]Non-cancer group is reference.[2]Adjusted for age, sex, race/ethnicity, and Charlson comorbidity index, which was calculated based on 12-month window and excluded cancer diagnoses. Age was not adjusted for breast cancer screening and colorectal cancer screening due to the tight age range of the included eligible subjects. Sex was not adjusted for breast cancer screening and cervical cancer screening.

3.5. *Breast cancer screening*

Breast cancer screening was recommended for 191 AYA cancer survivors (excluding primary breast cancer survivors and those considered high-risk for late effects). Among eligible patients, the mean PI was 79.7%, which did not differ significantly from the comparison group: 78.8% (Table 3). Using a PI cut-off point of 75%, there were no significant differences between the survivor and non-cancer groups in the logistic regression (Table 4).

3.6. *Cervical cancer screening*

Among the 3697 survivors eligible for cervical cancer screening, the mean PI was 87.4% versus 84.5% for the non-cancer comparison group (Table 3). The *t*-test to compare means revealed the between-group difference was significant (p-value: <0.01). Using a PI cut-off point of 75%, the logistic regression indicated that survivors were approximately 25% more likely to receive screening than the comparisons (OR: 1.26, 95% CI: 1.14–1.39, p-value: <0.01) (Table 4).

3.7. *Colorectal cancer screening*

The study population included 411 AYA cancer survivors eligible for colorectal cancer screening. The mean PI was approximately 25% greater for survivors then for the comparison group (83.23% vs. 58.27%, p-value: <0.01) (Table 3). Cancer survivors were five times more likely than the comparisons to have a mean PI of ≥ 75% (OR: 5.01, 95% CI: 3.82–6.55, p-value: <0.01) (Table 4).

4. Discussion

In light of the growing number of AYA cancer survivors, understanding their preventive health behaviors is essential for determining if targeted efforts are needed for long-term improvements in health and quality of life. Encouragingly, our findings suggest that AYA survivors have significantly higher adherence to USPSTF guidelines compared to the non-cancer group for all screening services except breast cancer, which did not differ significantly between the groups. The difference in mean PI between survivors and comparisons was <10% for dyslipidemia, hypertension, influenza vaccination, and cervical cancer screening, but was substantially greater (23.96%) for colorectal cancer screening. That said, we identified gaps in some screening services, such as influenza vaccination, dyslipidemia screening, and colorectal cancer screening, which could benefit from enhanced efforts to improve these preventive services among AYA cancer survivors.

Of all the preventive services examined, hypertension screening has the highest adherence with average screening coverage over 90% for the study period. This was the case for both cancer survivors and non-cancer subjects. However, the adjusted logistic regression model indicated that cancer survivors were more than four times more likely to have a PI ≥

75% for hypertension screening. Considering the recommended screening interval (every 2 years) and the standardized practice of checking blood pressure at every encounter at KPSC, it is likely that these results may be explained by differences in healthcare utilization rather than intentional compliance to screening guidelines. It is possible that greater healthcare utilization by cancer survivors may also in part explain their higher adherence to other preventive services. To this end, previous research has linked increased preventive service use to more frequent physician visits among survivors of adult-onset cancer, particularly if they are seeing both an oncologist and primary care physician (Snyder et al., 2008a, 2008b). These findings indicate that retaining AYAs in care will play a critical role for the long-term health outcomes of these cancer survivors.

While there is room for improvement in all screening services we assessed, influenza vaccination is the most notable. Although the mean PI among cancer survivors was nearly 10% higher than the non-cancer subjects (36.79% and 26.83%, respectively), it was still well under the Centers for Disease Control goal of over 80% coverage across the United States for the ages included in this study (Wurz and Brunet, 2019). A previous study examining adult survivors of childhood cancer and non-cancer subjects reported rates of influenza vaccine coverage similar to ours (Ojha et al., 2014). As cancer survivors have a greater risk of developing serious complications from influenza, it is particularly important that they receive yearly vaccinations (Bouwman et al., 2019). Our findings suggest that targeted efforts to increase influenza vaccination rates is warranted.

We found comparable rates of breast cancer screening among AYA cancer survivors and non-cancer subjects; however, survivors were significantly more likely to undergo cervical and colorectal cancer screenings at the intervals recommended by the USPSTF. This is largely in line with studies among older adult populations which have also reported higher rates of cancer screening among survivors (Trask et al., 2005), although the group differences appear to diminish over time after cancer diagnosis (LeMasters et al., 2014).

Our results indicate better preventive service use among survivors than non-cancer subjects, but there are certain limitations of this study to consider. First, we did not have several data elements that may influence the results of our adjusted models, such as individual-level education and income. Further, given that our sample population was fully insured during the study period, our findings may not be generalizable to individuals with minimal or inconsistent medical insurance coverage. That said, our study uniquely contributes to the literature data on preventive services utilization among AYA cancer survivors relative to their cancer-free peers when the insurance and access barriers are removed.

There are notable strengths of this study to mention as well. The use of medical records minimizes recall bias or inaccuracy of self-report, both of which are concerns when using a survey-based approach. In addition, our study assessed AYA cancer survivors treated and followed in a community oncology setting rather than a specialized survivorship clinic, which makes the results more generalizable to the majority of individuals with cancer. Our findings provide evidence and assurance that given equal and affordable access to health care, preventive service use is higher among AYA cancer survivors as opposed to age-matched comparisons. However, there are certain services which should receive additional attention—most notably influenza vaccination. It would be valuable for future research to investigate whether increased screening service use translates into prolonged survival or improved quality of life among AYA survivors, and to what extent.

Credit authorship contribution statement

Hilary C. Tanenbaum: Investigation, Writing - original draft, Writing - review & editing. **Lanfang Xu:** Data curation, Formal analysis, Investigation, Writing - review & editing. **Erin E. Hahn:** Conceptualization, Investigation, Writing - review & editing. **Julie Wolfson:** Conceptualization, Funding acquisition, Investigation, Writing - review & editing. **Smita Bhatia:** Conceptualization, Investigation, Writing - review & editing. **Kim Cannavale:** Project administration, Investigation, Writing - review & editing. **Robert Cooper:** Conceptualization, Investigation, Writing - review & editing. **Chun Chao:** Funding acquisition, Supervision, Investigation, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Compliance with ethical standards

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