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ORIGINAL ARTICLE

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Behavioural and psychosocial factors associated with 5-year weight trajectories within the PORTAL Overweight/Obesity Cohort

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Summary

Objective: The purpose of this study was to model weight trajectories over a 5-year time period (2012–2016) and their association with behavioural and psychosocial characteristics and health care–related experiences using data from the Patient Outcomes Research to Advance Learning (PORTAL) overweight/obesity cohort.

Methods: Weight trajectories for each eligible patient in the PORTAL overweight/obesity cohort (n = 2864) were identified first using growth modelling; trajectories were then grouped using a hierarchical cluster analysis. Weight trajectory clusters that emerged were compared on demographics, and predictors of cluster membership were examined. Clusters were also compared on responses to a survey assessing health behaviours, quality of life, and health care experience completed in 2015 by 49% of the total sample (n = 1391).

Results: Seven distinct weight trajectory clusters were identified: (a) significant weight loss then maintenance; (b) higher stable weight; (c) moderate stable weight; (d) steady weight loss then relapse; (e) weight gain then weight loss; (f) steady weight gain then maintenance; and (g) lower stable weight. Age, sex, race/ethnicity, and body mass index at baseline predicted patient's weight trajectory (P < .001). Over two thirds of patients maintained their weight over the 5-year period. Significant weight loss then maintenance, weight gain then weight loss, and higher stable weight patients were more likely to report receiving weight counselling from their provider. Patients in the significant weight loss then maintenance and lower stable weight clusters were more likely to be physically active than the other clusters.

Conclusion: Findings suggest variability in patterns of weight change among adults with overweight or obesity who have access to health care and that these patterns differ on demographic, behavioural and psychosocial factors, and health care experience.

KEYWORDS

obesity, population health, health behaviors, weight trajectories

1 | INTRODUCTION

Obesity prevalence in the United States has doubled since the 1960s,[1] and currently, 40% of adults in the United States have a body mass index (BMI) ≥ 30 kg m^2.[2] The increase in obesity prevalence is a result of a mostly steady incremental weight gain during young adulthood and middle age, notwithstanding initial weight status.[3] On the basis of the 2003–2012 National Health and Nutrition Examination Survey (NHANES), US adults with overweight/obesity who never smoked gained approximately 6 kg over 10 years, which is a little more than 1 lb per year.[4] Although a modest weight gain of 1 lb per year may go unnoticed during busy primary care visits, a recent large cohort study demonstrated that the risk for developing diabetes is three to six times higher for adults with obesity who continue to gain weight over time versus normal weight adults with no weight gain.[5] To further complicate the issue, once diagnosed with diabetes, adults with overweight/obesity who continue to gain weight also have worse glycaemic, blood pressure, and lipid control over time, along with a commensurate increase in health care costs, than those who lose weight or maintain their weight over time.[6-9] Thus, continuous weight gain among individuals with overweight/obesity increases risk for diabetes, cardiovascular disease, certain types of cancer, mobility limitations, and mortality.[4,6]

Associations between weight gain and health complications and between weight loss or maintenance over time and disease prevention or management are well-established.[5-10] In contrast, associations between weight trajectories (ie, patterns of weight change) and behavioural and psychosocial factors are less clear. Previous studies using clinical trial data to examine behavioural and psychosocial factors associated with weight trajectories have limited generalizability because these studies only reflect postintervention trajectories of individuals in rigorous behavioural weight loss interventions.[8,11-13] From a population health perspective, modelling natural weight trajectories may help to identify populations at high risk for obesity-related chronic diseases. A health systems cohort provides an advantage of multiple assessments of weight in a realistic setting. In addition, identifying the behavioural and psychosocial factors associated with different weight trajectories may lead to the development of tailored obesity treatments.

The purpose of this study was to model weight trajectories over a 5-year time period (2012–2016) among adults with overweight or obesity, examine demographic characteristics, and establish health behaviours, psychosocial factors, and health care experiences, assessed using a survey, associated with the weight trajectories that emerged.

2 | METHODS

2.1 | Data source

Data for this study came from the Patient Outcomes Research to Advance Learning (PORTAL) adult overweight and obesity cohort.[14] PORTAL was one of the Clinical Data Research Networks within the Patient-Centered Outcomes Research Network (PCORnet) and consists of 11 million patients across nine states from four health care delivery systems in the United States. These systems include all eight regions of Kaiser Permanente: Hawaii, Northwest (including Northern Oregon and Southwest Washington), Northern California, Southern California, Colorado, Mid-Atlantic States (including Maryland, Virginia, and the District of Columbia), Washington, and Georgia; Health Partners (including Minnesota and Wisconsin); and Denver Health.

As described in detail elsewhere,[14] the PORTAL cohort includes more than 5 million individuals with overweight and obesity and reflects the underlying regional race, ethnicity, and neighbourhood education and income distributions of the participating health systems. In a previous analysis of this cohort, the prevalence of hypertension was greater for Blacks, American Indians/Alaska Natives, Asians, and Native Hawaiians/Pacific Islanders compared with Whites despite being in the same BMI category and neighbourhood education level.[15] Furthermore, racial/ethnic minorities in this cohort had a higher burden of prediabetes and diabetes at lower BMIs than Whites.[16] This current analysis included data from six of the Kaiser Permanente PORTAL sites: Kaiser Permanente Northwest, Northern California, Southern California, Colorado, Mid-Atlantic States, and Hawaii. Demographic, weight, and other clinical data were extracted using the PCORnet Common Data Model in which all data reside behind each site's security system or firewall.[17] The Kaiser Permanente Southern California's Institutional Review Board (IRB) approved this study. The IRBs at the other participating sites reviewed the protocol and subsequently ceded review.

2.2 | Participants

For this study, inclusion criteria consisted of (a) age 18 and older; (b) Kaiser Permanente health plan member for at least 12 continuous months between 1 January 2012 and 31 December 2013 (dates when the cohort was first created); (c) overweight or obesity (BMI > 25.0 kg m^2; Asians with BMI ≥ 23.0 kg m);[18] (d) had an outpatient visit in the past 12 months; (e) not pregnant during the study time period (2012–2016); and (f) be one of 5400 patients who were randomly invited to complete the PORTAL Health Survey by mail in 2015 (see description below), 3 years after baseline weight. Among the six participating Kaiser Permanente regions, 3989 patients met these inclusion criteria. Patients were excluded if they did not have a weight and height measurement between 2012 and 2013 to calculate baseline BMI and if they had fewer than four weight measurements (needed to model trajectories), leaving a total analytic sample of 2864. Participants who were included in the hierarchical cluster analysis compared with those excluded were older ($P < .001$), consisted of higher percentage of females ($P = .01$), and had higher prevalence of prediabetes ($P < .01$), diabetes ($P < .001$), and hypertension ($P < .001$) diagnoses. Of the 2864 included in the hierarchical cluster analysis, 1391 (49%) completed the PORTAL Health Survey by mail in 2015.

2.3 | Measures

Weight was measured during outpatient encounters and recorded in the electronic medical record (EMR). The analysis included all weights documented in the EMR from 2012 to 2016. Race and ethnicity information were obtained from health plan administrative data, membership data, EMR, and birth records. Race/ethnicity was categorized as non-Hispanic White, Hispanic (regardless of race), non-Hispanic Black, Asian, Pacific Islander, and other (unknown or other race/ethnicity).

The prevalence of hypertension, diabetes, and prediabetes in the cohort was determined from the EMR. Hypertension was defined as at least two outpatient visits or one inpatient hospitalization with coded diagnosis. Diabetes was defined using the methodology from the Surveillance, Prevention, and Management of Diabetes Mellitus (SUPREME DM) large multisite observational diabetes study[19] and based on the American Diabetes Association definition.[20] Specifically, the definition for diabetes included one inpatient diagnosis of diabetes or any combination of two other events (outpatient diagnosis, dispense of an anti-hyperglycaemic medication, glycated haemoglobin [HbA_{1c}] equal to or greater than 6.5%, fasting plasma glucose equal to or greater than 126 mg dL^{-1}, or random plasma glucose equal to or greater than 200 mg dL^{-1}). Prediabetes was defined as at least one HbA_{1c} between 5.7% and 6.4%, at least one fasting plasma glucose measurement between 100 and 125 mg dL^{-1}, at least one glucose tolerance test between 140 and 199 mg dL^{-1}, or at least one diagnosis code.

The PORTAL Health Survey consisted of items to assess health-related quality of life, particularly physical functioning and mental well-being (SF-8),[21] symptoms of depression and anxiety (PHQ-4),[22] sleep, dietary intake (starting the conversation),[23] minutes of moderate-to-vigorous physical activity per week using exercise as a vital sign,[24] weight history, behavioural strategies to lose weight, and quality of health care related to weight management.

2.4 | Statistical analysis

First, individual weight trajectories for the total sample of 2864 participants were estimated using a growth curve analysis. This full sample was employed for the growth curve and hierarchical cluster analysis in order to obtain more representative parameter estimates. Both linear and quadratic models were tested and compared using Akaike information criterion (AIC) and Bayesian information criterion (BIC), where a smaller value is better, to determine best fit for the data.

Intercept and slope parameters describing individual weight trajectories were then entered into a hierarchical cluster analysis.[25,26] Groups of participants with similar weight trajectories (ie, similar in intercept and slopes) were identified using the Ward method. Models with 1 to 15 clusters were tested, and the number of clusters was selected by examining three diagnostic graphs: the cubic clustering criterion (CCC), the pseudo-*F* statistic, and the pseudo-*t* statistic. The semipartial *R*-squared and *R*-squared values also contributed in the selection of the numbers of clusters. Discriminant analysis and canonical correlations were performed after the number of clusters was selected to report percentage of individuals correctly classified and the total variance explained.

The subgroups or clusters that emerged using data from the total sample (n = 2864) were compared on demographics using analysis of variance (ANOVA) (Kruskal-Wallis tests) and chi-square tests while applying a Bonferroni correction for multiple comparisons and considering a *P* value of less than.008 as significant. Univariate multinomial logistic models were performed to examine predictors of cluster membership with age, sex, race/ethnicity, baseline BMI, and tobacco use (yes/no) as predictors; significant predictors were then included in a multivariable multinomial logistic model. Limited to the subsample that completed the survey (n = 1391), clusters were also compared on survey responses using ANOVA Kruskal-Wallis tests for continuous measures and chi-square test for categorical. All analyses were performed using SAS, version 9.4 (SAS Institute Inc, Cary, North Carolina).

3 | RESULTS

3.1 | Sample characteristics

Table 1 presents the demographic and clinical characteristics of the total sample (n = 2864) and subsample of participants who completed the PORTAL Health Survey (n = 1391). The total sample consisted of approximately 62% women and 50% non-Whites. The median age was 57 (interquartile range [IQR] 45, 66), and median BMI was 37 (IQR 31, 42). Approximately 30% of the participants met the criteria for diabetes, 38% for prediabetes, and 48% for hypertension.

3.2 | Weight trajectory clusters

For the total sample, there were 22 476 weight measurements documented in the EMR over the 5 years, an average of 7.85 measurements per person (range = 4–11). When the weight trajectories was estimated, the quadratic model had a lower AIC and BIC, suggesting that it fit the data better than the linear model. Therefore, each individual weight trajectory consisted of an intercept (initial weight at enrolment into the cohort), linear slope (weights from 2012 to 2016), and a quadratic slope. Overall, participants in the cohort maintained their weight over the 5-year observational period (Figure 1).

Based on the CCC, pseudo-*F* statistic, and pseudo-*t* statistic diagnostic graphs as well as meaningfulness of the clusters, a seven-cluster solution was selected (ie, seven distinct weight trajectories; Figure 1). Approximately 76% of the variance in cluster membership was explained by the seven-cluster quadratic model, and 82% or more of participants were appropriately classified in each cluster, increasing our confidence in the seven-cluster quadratic model. The "higher stable weight" (n = 548, 18%), "moderate stable weight" (n = 669, 23%), and "lower stable weight" (n = 726, 25%) clusters primarily maintained their weights over the 5-year observational period. The "significant weight loss then maintenance" group (n = 98, 3%) lost on average 12% (95% CI, −15.25 to −9.10) of their initial weight in the first

TABLE 1 Baseline sample characteristics

	All Patients (*N* = 2864)	Patients Who Completed Survey (*N* = 1391)
Age in y, median (IQR)	57 (45, 66)	58 (47, 67)
Female, n (%)	1,071 (62)	865 (62)
Baseline BMI, kg m^{-2}, median (IQR)	37 (31, 42)	36 (31, 42)
Baseline weight, median (IQR)	227 (189, 267)	225 (188, 265)
Race/ethnicity, n (%)		
White non-Hispanic	894 (51)	741 (53)
Black non-Hispanic	298 (17)	229 (17)
Hispanic	260 (15)	178 (13)
Asian	117 (7)	97 (7)
Hawaiian/Pacific Islander	115 (7)	97 (7)
Other	57 (3)	49 (3)
Bariatric surgery, n (%)	58 (2)	29 (2)
Tobacco use, n (%)	258 (9)	98 (7)
Hypertension, n (%)	843 (48)	684 (49)
Prediabetes, n (%)	663 (38)	551 (40)
Diabetes, n (%)	490 (28)	372 (27)

Note. Data for age, sex, race/ethnicity, hypertension, prediabetes, and diabetes are based on patients who were invited to complete the PORTAL Health Survey and who had these data available in the electronic medical record (*n* = 1741). Other race/ethnicity is defined as those who either have "other" or unknown for race/ethnicity in the various data sources used to obtain race/ethnicity. Hypertension was defined as at least two outpatient visits or one inpatient hospitalization with coded diagnosis. Diabetes was defined as one inpatient diagnosis of diabetes or any combination of two other events (outpatient diagnosis, dispense of an anti-hyperglycaemic medication, HbA_{1c} equal or greater than 6.5%, fasting plasma glucose equal or greater than 126 mg dL, or random plasma glucose equal or greater than 200 mg dL^{-1}). Prediabetes was defined as at least one HbA_{1c} between 5.7% and 6.4%, at least one fasting plasma glucose measurement between 100 and 125 mg dL^{-1}, at least one glucose tolerance test between 140 and 199 mg dL^{-1}, or at least one diagnosis code.

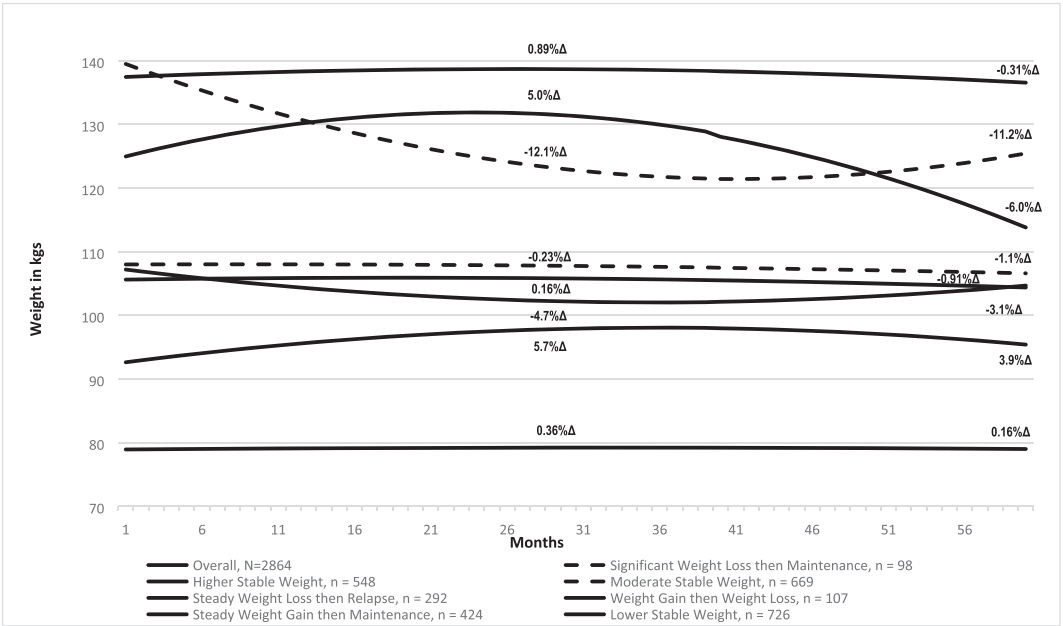

FIGURE 1 Patient Outcomes Research to Advance Learning (PORTAL) overweight/obesity cohort 5-year weight trajectories. *Note.* Percent weight changes (month 30-month 0 [95% confidence intervals]; month 60-month 0 [95% confidence intervals])—overall (0.16 [−0.31 to 0.63]; −0.91 [−2.06 to 0.22]); significant weight loss then maintenance (−12.06 [−15.25 to −9.10]; −11.15 [−17.97 to −4.83]); higher stable weight (0.89 [0.29–1.48]; −0.31 [−1.76 to 1.12]); moderate stable weight (−0.23 [−0.55 to 0.09]; −1.10 [−1.87 to −0.34]); steady weight loss then relapse (−4.73 [−5.49 to −3.99]; −3.08 [−4.75 to −1.46]); weight gain then weight loss (5.01 [3.05–6.83]; −5.97 [−11.47 to −0.88]); steady weight gain then maintenance (5.74 [5.15–6.31]; 3.85 [2.35–5.32]); lower stable weight (0.36 [−0.07 to 0.80]; 0.16 [−0.88 to 1.19])

30 months and largely maintained that weight loss thereafter. For the "steady weight loss then relapse" group (n = 292, 10%), weight decreased by 4.7% (95% CI, −5.49 to −3.99), on average, over the first 30 months followed by weight regain almost to their baseline weight. In the "weight gain then weight loss" group (n = 107, 4%), there was significant weight gain for the first 30 months (5% increase; 95% CI, 3.05–6.83) followed by weight loss. Lastly, the "steady weight gain then maintenance" group (n = 424, 15%) gained on average 5.7% (95% CI, 5.15–6.31) of their initial weight over 30 months and then maintained their weight thereafter.

3.3 | Baseline characteristics by weight trajectory clusters (total sample)

Demographic characteristics of each cluster are presented in Table 2 for the total sample. There were significant differences in age, baseline BMI, percent female, race/ethnicity, and prevalence of hypertension and diabetes across clusters. Specifically, patients in the lower stable weight group were older (median age = 61; IQR 50,70). The steady weight gain then maintenance group (71%) followed by the lower stable weight group (69%) had the highest percent of women. Patients in the significant weight loss then maintenance (median BMI = 48; IQR 40, 52), higher stable weight (median BMI = 45; IQR 41, 50), and weight gain then weight loss (median BMI = 41; IQR 37, 46) had median baseline BMIs in the class III obesity category, whereas the moderate stable weight (median BMI = 39; IQR 35, 42) and steady weight loss then relapse (median BMI = 39; IQR 35, 44) groups were borderline class III obesity; and the steady weight gain then maintenance (median BMI = 34; IQR 30, 38) and lower stable weight (median BMI = 29; IQR 27, 32) groups were class II and class I, respectively. Approximately 18% of the patients in both the significant weight loss then maintenance and weight gain then weight loss groups had bariatric surgery. Among racial/ethnic minorities, a majority of the non-Hispanic Blacks were in the higher stable weight group, and a larger proportion of Hispanics were in the steady weight gain then maintenance group.

Based on results from the univariate multinomial logistic models (not shown), age, sex, baseline BMI, and race/ethnicity were included in the multivariable multinomial logistic model (Table 3). Higher age was associated with a lower likelihood of belonging to any of the other groups compared with the lower stable weight group (reference). Compared with men, women were significantly less likely to be in the other weight trajectory groups compared with being in the lower stable weight group. Participants with a higher BMI at baseline were significantly more likely to be in any group other than the lower stable weight group. Non-Hispanic Black participants were less likely to be in the weight gain then weight loss cluster than the lower stable weight cluster compared with White participants (OR = 0.41; 0.17, 0.98). In addition, compared with Whites, Hispanics and others were less likely to be in any other weight trajectory group, with the exception of the steady weight gain then maintenance, than the lower stable weight group.

TABLE 2 Sample characteristics by cluster, n = 2864

	Significant Weight Loss then Maintenance (n = 98)	Higher Stable Weight (n = 548)	Moderate Stable Weight (n = 669)	Steady Weight Loss then Relapse (n = 292)	Weight Gain then Weight Loss (n = 107)	Steady Weight Gain then Maintenance (n = 424)	Lower Stable Weight (n = 726)	P Value
Age, median (IQR)	56.0 (46, 66)	52.0 (41, 63)	58.0 (49, 66)	58.5 (48, 67)	50.0 (42, 62)	55.0 (43, 66)	61.0 (50, 70)	<.001
Female, n (%)	33 (60)	154 (47)	248 (59)	115 (67)	38 (52)	177 (71)	306 (69)	<.001
BMI, median (IQR)	48 (40, 52)	45 (41, 50)	39 (35, 42)	39 (34, 44)	41 (37, 46)	34 (30, 38)	29 (27, 32)	<.001
Race/ethnicity, n (%)								
White non-Hispanic	34 (62)	158 (48)	225 (54)	100 (58)	44 (60)	111 (45)	222 (50)	<.001
Black non-Hispanic	10 (18)	83 (25)	75 (18)	27 (16)	11 (15)	36 (15)	56 (13)	
Hispanic	5 (9)	44 (13)	62 (15)	23 (13)	6 (8)	52 (21)	68 (15)	
Other	6 (11)	43 (13)	56 (13)	22 (13)	12 (16)	49 (20)	101 (23)	
Hypertension, n (%)	32 (58)	180 (55)	220 (53)	82 (48)	38 (52)	100 (40)	191 (43)	<.001
Prediabetes, n (%)	23 (42)	125 (38)	150 (36)	63 (37)	28 (38)	96 (39)	178 (40)	.92
Diabetes, n (%)	23 (42)	113 (35)	142 (34)	58 (34)	22 (30)	52 (21)	80 (18)	<.001

Note. Data for age, sex, race/ethnicity, hypertension, prediabetes, and diabetes are based on patients who were invited to complete the PORTAL Health Survey and who had these data available in the electronic medical record (n = 1741); n, % of those invited to take survey—significant weight loss then maintenance (55, 56%), higher stable weight (328, 60%), moderate stable weight (418, 63%), steady weight loss then relapse (172, 59%), weight gain then weight loss (73, 68%), steady weight gain then maintenance (248, 59%), and lower stable weight (447, 62%).

TABLE 3 Demographic predictors of weight trajectory cluster membership

	Significant Weight Loss then Maintenance		Higher Stable Weight		Moderate Stable Weight		Steady Weight Loss then Relapse		Weight Gain then Weight Loss		Steady Weight Gain then Maintenance		Lower Stable Weight
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	Reference
Age	0.97	0.94–0.99	0.94	0.93–0.96	0.98	0.96–0.99	0.98	0.96–0.99	0.94	0.92–0.96	0.97	0.96–0.98	
Female	0.01	0.01–0.03	0.01	0.00–0.01	0.07	0.04–0.11	0.10	0.06–0.17	0.02	0.01–0.04	0.47	0.31–0.70	
Male	1.00	---	1.00	---	1.00	---	1.00	---	1.00	---	1.00	---	
BMI	2.30	2.13–2.48	2.25	2.11–2.41	1.71	1.62–1.81	1.71	1.61–1.82	2.04	1.89–2.19	1.30	1.24–1.36	
Race/ethnicity													
White non-Hispanic	1.00	---	1.00	---	1.00	---	1.00	---	1.00	---	1.00	---	
Black non-Hispanic	0.48	0.19–1.22	0.86	0.45–1.65	0.69	0.40–1.21	0.53	0.28–1.03	0.41	0.17–0.98	0.78	0.46–1.33	
Hispanic	0.10	0.03–0.33	0.16	0.08–0.33	0.38	0.22–0.68	0.32	0.16–0.64	0.09	0.03–0.26	0.97	0.59–1.57	
Other	0.12	0.04–0.36	0.15	0.07–0.32	0.33	0.19–0.57	0.29	0.15–0.56	0.21	0.09–0.50	0.67	0.41–1.08	

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

3.4 | Survey responses by weight trajectory cluster (survey subsample)

Table 4 presents results from the comparison tests on items from the survey (*n* = 1391). There were no significant group differences for the SF-8 mental health composite, servings of fruits and vegetables per day, or servings of sugar-sweetened beverages per day. There were significant group differences for the SF-8 physical health composite score, PHQ-4, and minutes of physical activity per week (based on exercise as a vital sign).[24] For the physical health composite score, patients in the lower stable weight group (median = 59; IQR 49, 64) scored well above the median for the US-based normative scale (median = 52; IQR 44, 56),[21] whereas patients in the significant weight loss then maintenance (median = 49; IQR 40, 60) and weight gain then weight loss (median = 49; IQR 40, 59) groups scored below the US-based normative scale. The weight gain then weight loss group also endorsed more symptoms of depression and anxiety on the PHQ-4 (median = 2; IQR 0, 5). The significant weight loss then maintenance cluster reported the highest median minutes of physical activity (median = 150; IQR 0, 280) and had the highest proportion of patients (52%) reporting 150 minutes or more of physical activity per week followed by 46% of the lower stable weight group.

In terms of weight history, the significant weight loss then maintenance group had the highest proportion of patients report that they had tried to lose weight in the past 12 months (92%) followed by the weight gain then weight loss group (87%) (Table 4). There were also significant overall group differences in perceived provider involvement in weight management efforts. A higher proportion of participants in the weight gain then weight loss cluster (48%) endorsed that their provider "frequently" brought up their weight during a clinic visit. Approximately 50% or more of patients within each weight trajectory group endorsed that their provider was "frequently" supportive of their weight concerns and efforts to become healthy with the exception of the lower stable weight group where only 38% endorsed that their provider was "frequently" supportive. Although approximately half or more of the patients in each group endorsed discussing or receiving resources on healthy eating and weight loss from their provider, this was particularly evident in the weight gain then weight loss (80%), significant weight loss then maintenance (78%), and higher stable weight (74%) groups.

4 | DISCUSSION

Seven distinct 5-year weight trajectories were identified in a diverse health system-based cohort of adults with overweight and obesity: (a) significant weight loss then maintenance; (b) higher stable weight; (c) moderate stable weight; (d) steady weight loss then relapse; (e) weight gain then weight loss; (f) steady weight gain then maintenance; and (g) lower stable weight. These trajectories are fairly consistent with trajectories established in previous cohort studies.[6,10,27] Age, sex, race/ethnicity, and BMI at baseline significantly predicted patients' membership in a weight change trajectory cluster. In

TABLE 4 Survey responses by cluster: median (IQR)

	Significant Weight Loss then Maintenance (n = 98)	Higher Stable Weight (n = 548)	Moderate Stable Weight (n = 669)	Steady Weight Loss then Relapse (n = 292)	Weight Gain then Weight Loss (n = 107)	Steady Weight Gain then Maintenance (n = 424)	Lower Stable Weight (n = 726)	*P* Value
Survey completed—n (%)	38 (39)	250 (46)	326 (49)	128 (44)	67 (63)	196 (46)	386 (53)	
SF-8 Physical Health Composite Score	49 (40, 60)	52 (44, 60)	57 (48, 62)	51 (44, 61)	49 (40, 59)	55 (47, 62)	59 (49, 64)	<.001
SF-8 Mental Health Composite Score	63 (58, 66)	61 (54, 68)	63 (57, 68)	63 (56, 68)	57 (46, 64)	62 (57, 68)	62 (56, 68)	.01
PHQ-4	1 (0, 2)	1 (0, 4.0)	0 (0, 3)	0 (1, 3)	2 (0, 5)	1 (0, 4)	1 (0, 3)	.001
Minutes of MVPA wk^{-1}	150 (0, 280)	60 (0, 150)	100 (0, 180)	80 (0, 225)	85 (0, 150)	90 (0, 180)	120 (45, 240)	<.001
Physical activity ≥150 min wk^{-1}—n (%)	12 (52)	44 (26)	78 (37)	29 (36)	14 (33)	51 (39)	118 (46)	.004
Servings of sugar-sweetened beverages per day	0 (0, 1)	0 (0, 1)	0 (0, 1)	0 (0, 1)	0 (0, 2)	0 (0, 1)	0 (0, 1)	.02
Servings of fruits/vegetables per day	2 (2, 4)	2 (1, 3)	2 (1, 3)	3 (2, 4)	2 (1, 4)	2 (2, 3)	2 (1, 3)	.02
During past 12 mo, have you tried to lose weight?—Yes, n (%)	34 (92)	201 (81)	236 (75)	105 (83)	58 (87)	144 (74)	248 (67)	<.001
How often has your provider brought up weight at any clinic visit?—n (%)								<.001
Frequently	13 (37)	95 (40)	87 (28)	21 (18)	30 (48)	42 (23)	38 (11)	
Sometimes	16 (46)	117 (49)	175 (57)	75 (63)	28 (45)	79 (44)	140 (41)	
Never	6 (17)	26 (11)	44 (14)	24 (20)	4 (6)	60 (33)	164 (48)	
How often do you avoid seeing provider because you do not want to be weighed or talk about weight?—n (%)								<.001
Frequently	2 (6)	17 (7)	10 (3)	4 (3)	0 (0)	7 (4)	8 (2)	
Sometimes	4 (11)	45 (19)	40 (13)	20 (17)	11 (18)	19 (11)	23 (7)	
Never	30 (83)	173 (74)	256 (84)	97 (80)	50 (82)	148 (85)	316 (91)	
How often does your provider ask permission before discussing your weight with you?—n (%)								.002
Frequently	3 (10)	13 (6)	23 (10)	1 (11)	7 (13)	15 (10)	9 (3)	
Sometimes	4 (14)	29 (14)	24 (10)	7 (8)	9 (16)	9 (6)	20 (7)	
Never	22 (76)	167 (80)	193 (80)	82 (91)	40 (71)	121 (84)	244 (89)	
How often is your provider supportive of your weight concerns and efforts to become healthy?—n (%)								<.001
Frequently	18 (50)	129 (59)	135 (52)	53 (53)	37 (65)	75 (50)	101 (38)	
Sometimes	15 (42)	57 (26)	81 (31)	31 (31)	14 (25)	51 (34)	80 (30)	
Never	3 (8)	31 (14)	43 (17)	17 (17)	6 (11)	23 (15)	85 (32)	

(Continues)

TABLE 4 (Continued)

	Significant Weight Loss then Maintenance (n = 98)	Higher Stable Weight (n = 548)	Moderate Stable Weight (n = 669)	Steady Weight Loss then Relapse (n = 292)	Weight Gain then Weight Loss (n = 107)	Steady Weight Gain then Maintenance (n = 424)	Lower Stable Weight (n = 726)	P Value
Has your provider ever discussed or given you resources on healthy eating and weight loss?—Yes, n (%)	29 (78)	179 (74)	208 (66)	84 (68)	52 (80)	114 (60)	171 (48)	<.001

Note. Survey sample size is 1391, 49% of total sample. Applying a Bonferroni correction for multiple comparisons, a *P* value less than.008 was considered significant.
Abbreviation: MVPA, moderate-to-vigorous physical activity.

addition, the weight trajectories differed on exercise habits, health-related quality of life, symptoms of depression, and health care experience.

Most of the patients in the PORTAL overweight/obesity cohort (68%) maintained their weight over the 5-year period as represented by the higher stable weight, moderate stable weight, and lower stable weight clusters that emerged. This finding is consistent with the Swedish Obese Subjects (SOS) control cohort, which had minimal weight change over 15 years.[28] At baseline, more than half of those in the higher stable weight and moderate stable weight groups had hypertension, and over one third had diabetes. In addition, higher stable weight patients self-reported the lowest minutes of exercise per week (median of 60 min), and 25% consisted of non-Hispanic Blacks, a high-risk group for cardiovascular disease. On the basis of previous research, patients who maintained a higher stable weight over 3 years were one to two times more likely to have uncontrolled hypertension and diabetes at follow-up than were those who lost weight.[6] Therefore, patients who fall into the Higher Stable or Moderate Stable weight trajectories may benefit from close monitoring of clinical measures and referral to intensive weight loss programmes. On the other hand, the lower stable weight group was unique in that they were the most active among the stable weight groups (46% achieving 150 min of exercise per week) and self-reported the highest composite score for physical functioning. Given the benefits of physical activity in terms of weight maintenance and overall well-being,[29] this group may benefit from physical activity counselling from their providers and connection to physical activity resources.

Over one third of patients in the PORTAL Overweight/Obesity Cohort did not maintain their initial weight over the 5-year period. Specifically, the steady weight gain then maintenance trajectory is a consistent weight change pattern found in other US,[3,4] Canadian,[27] and Chinese[10] cohort studies. The steady weight loss then relapse group represents the experience of most individuals who try to lose weight but are unsuccessful long term. Regular exposure to an obesogenic environment could certainly explain these trajectories in combination with perhaps a lack of support to make healthy changes. Although social support was not directly assessed in this study, only 18% and 23% of steady weight loss then relapse and steady weight gain then maintenance patients, respectively, self-reported that their provider "frequently" brought up their weight during a clinic visit. Patients who are steadily gaining weight at each visit or are attempting to lose weight, but facing challenges, may benefit from close follow-up early on regarding their weight change pattern, assessment of their readiness to lose weight, and referral to weight management programmes.

Only two clusters represented clinically significant weight loss patterns over the 5-year period, significant weight loss then maintenance, and weight gain then weight loss. Patients in both groups had baseline BMIs in the class III obesity category and had a high prevalence of obesity-related chronic conditions (ie, hypertension, prediabetes, or diabetes), which may speak to their motivation to lose weight. Approximately 18% of patients in both groups had bariatric surgery at some point during the 5-year period. In addition, patients in

the significant weight loss then maintenance group self-reported engaging in a median of greater than or equal to 150 minutes of exercise per week with more than half self-reporting meeting physical activity guidelines,[30] which is consistent with findings from the National Weight Control Registry.[31] However, both groups scored lower than the US-based normative scale for health-related physical functioning, and the weight gain then weight loss group endorsed more symptoms of depression than did the other groups at the time of the survey (which was administered 2- to 3-years post baseline). Unfortunately, quality of life and depression were not reassessed at a later time point to examine if this finding persisted or if well-being improved with weight loss over time as demonstrated in previous clinical trials.[32]

Health care experience regarding weight management support differed across the weight trajectory clusters. Over 83% of patients within clusters that had some weight loss over the 5-year period (ie, significant weight loss then maintenance, weight gain then weight loss, and steady weight loss then relapse) self-reported trying to lose weight in the past 12 months, and over 50% reported support from their providers in their weight loss efforts. Previous studies have demonstrated that brief weight loss counselling from the provider is associated with increased patient motivation to make dietary changes and lose weight.[33,34] Clusters with class III obesity and a high prevalence of obesity-related chronic conditions at baseline (ie, significant weight loss, higher stable weight, moderate stable weight, and weight gain then weight loss) were more likely to report frequently having conversations with their health care provider about their weight than was the lower stable weight cluster. This is consistent with findings from national survey data that individuals with obesity who are at moderate or high risk for co-morbidities and mortality are more likely to receive weight counselling than those with obesity and low risk for co-morbidities and mortality.[35]

There were several limitations in this study. First, the cohort was limited to a clinical population with overweight or obesity at baseline, and findings are unlikely to generalize to a general population sample. Second, the PORTAL Health Survey was administered in 2015, 3 years after baseline weight (2012), so the behavioural and psychosocial measures that were assessed could not be examined as predictors, only as measures associated with weight trajectory. Furthermore, eating habits and level of physical activity were self-reported. Also, the survey covered limited domains and did not address participant access to weight loss programmes, neighbourhood walkability, or social support for healthy eating. There was also no secondary measure of whether weight management counselling occurred during medical encounters to corroborate self-report on the survey. Biases in terms of who chose to respond to the survey may have influenced item responses, particularly on the question about whether participants avoid seeing a provider because of not wanting to discuss weight.

As previously mentioned, those included in the analysis were more likely to be older, were female, and have a diagnosis of prediabetes, diabetes, or hypertension than were those who were excluded. Given these characteristics and the fact that the weights were obtained during medical encounters, those included in the analysis may be higher utilizers of health care than those excluded from the analysis, and those who were excluded may have presented a different set of trajectories reflecting a healthier cohort of patients with lower health care utilization.

Finally, it should be noted that women who had a pregnancy during the study period were excluded from the study. While weight trajectories associated with pregnancy and the postpartum period were outside the scope of our study, excess gestational weight gain and postpartum weight retention are common and increase lifetime risk for obesity; pregnancy is thus an important factor that can alter weight trajectories.[36-39]

In conclusion, using a hierarchical cluster analysis, seven distinct weight trajectories over a 5-year period were identified in a diverse, health care–based cohort of adults with overweight and obesity. Overall, findings suggest that there is quite substantial variability in patterns of weight change even among a cohort of adults with access to health care and that demographic, behavioural, and psychosocial factors associated with these patterns differ. Future studies are needed to not only capture additional factors potentially associated with weight trajectories that were not assessed in this study (eg, neighbourhood walkability and access to healthy foods) but also capture them as early as possible when the cohort is being formed. Finally, further work is needed to understand what strategies for weight loss are being implemented by those exhibiting a weight loss trajectory.

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CONFLICT OF INTEREST

No conflict of interest was declared.

AUTHOR CONTRIBUTIONS

Fitzpatrick performed the conceptualization, writing of the original draft, review, and editing. Rosales performed the conceptualization, formal analysis, writing of the original draft, review, and editing. Brown, Arterburn, Daley, Horberg, Koebnick, Oshiro, and Young performed the review and editing.

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