Supplementary material

Supplemental Table 1. characteristics of participants in analytic sample and excluded samples during this study

Characteristic	*Analytic Sample*		*Excluded sample*		*Statistics* *	*P*
	missing		*missing*			
No. Participants		14185		19222		
Age (y)	21 (0.1%)	41.4 ± 15.0	11	23.9±21.7	6611.02	<0.01
Female (%)		7546 (53.2%)		9802 (51.0%)	15.9	<0.01
Education year (y)	1387 (9.8%)	6.6 ± 4.2	6732 (35.0%)	7.2±4.4	141.7	<0.01
Never		2309 (18.0%)		1092 (8.7%)		
<6 years		2708 (21.2%)		3507 (28.1%)		
6-8 years		2281 (17.8%)		2205 (17.7%)	814.4	<0.01
9-11 years		3872 (30.3%)		3158 (25.3%)		
>12 years		1628 (12.7%)		2528 (20.2%)		
Rural (%)		9072 (64.0%)		11654 (60.6%)	38.3	<0.01
Income (yuan in 2011)	2472 (17.4%)	6335.0 ± 10313.2	12074 (62.8%)	17033.2±25486.7	1527.9	<0.01
Behavior						
Cigarette Smoker (%)	229 (1.6%)	4566 (32.7%)	5981 (47.2%)	2311 (22.8%)	837.9	<0.01
Alcohol Drinker (%)	103 (0.7%)	5175 (36.8%)	4420 (34.9%)	2913 (23.2%)	1042.9	<0.01
Physical Activities (MET-hours/day)	440 (3.1%)	6.7 ± 10.9	6914 (36.0%)	11.7±15.2	880.7	<0.01
Anthropometry at baseline						
Height (cm)	359 (2.5%)	160.5 ± 8.4	3084 (16.0%)	138.1±32	6089.4	<0.01
Weight (Kg)	438 (3.1%)	57.4 ± 10.2	2866 (14.9%)	41.9±23	5136.0	<0.01
BMI (kg/m^2)	446 (3.1%)	22.2 ± 3.1	3203 (16.7%)	20.1±5	1698.4	<0.01
Lean (<18.5)		1586 (11.2%)		6903 (43.1%)		
Normal (18.5~23.9)		9145 (64.5%)		6019 (37.6%)	4474.8	<0.01
Overweight (24~27.9)		2781 (19.6%)		2252 (14.1%)		
Obesity (≥28)		673 (4.7%)		845 (5.3%)		
Systolic BP (mm Hg)	378 (2.7%)	116.7 ± 17.7	7136 (37.1%)	112.2±20	334.6	<0.01
Diastolic BP (mm Hg)	378 (2.7%)	75.9 ± 11.2	7133 (37.1%)	72.2±13	589.4	<0.01
Dietary Total Energy (kcal)	391 (2.8%)	2473.7 ± 755.5	2555 (13.3%)	1853.9±1396	2212.2	<0.01
No. of participants with type 2 diabetes		522 (3.7)		296 (1.5%)	156.5	<0.01

Values in table are Mean ± SD or N (Percent); Missing data are handled in the analysis; BMI, body mass index; BP, blood pressure

* F value for continues variable and Chi square for category variable.

Supplemental ·Text. The model fitting procedure of BMI change trajectory and goodness of model fitting

Using a maximum-likelihood approach, LCTA estimated multiple regression models simultaneously and calculated from the model parameters the probability of each participants belonging to each trajectory group. The model fitting procedure of BMI change trajectory with Proc Traj is listed as follows:

Step 1. Decide on the optimal number of groups using substantive knowledge. Based on previous researches(1, 2) and our substantive knowledge about the long-term change of BMI characteristics, we decided to fit two- to five-group models of BMI change trajectories.

Step 2. Fit number of groups to data. To determine the optimal number of trajectory groups included in the model, we compared Bayesian Information Criteria (BIC) between models with different groups. A smaller BIC value indicated a better fit(3), but as the number of groups was increased across models, the additional reduction of BIC became smaller (**Supplemental Table 2**). Following the existing guidelines(4, 5), we chose the model when additional groups failed to increase BIC by at least half of the BIC in the previous model and the value of group membership probability ≥5%.

Step 3. Select the shape of the pattern of change for each group over time. After the number of groups was selected, we determined further the shape of each trajectory group using a stepwise approach in establishing polynomial order, with all groups initially set to cubic order. As the order of each trajectory was set to quadratic, linear, and intercept respectively, we compared the changes in BIC and the significance of parameters across models. Based on the substantive knowledge and statistical inference, the cubic trajectory pattern with four trajectory groups was regarded as the best fitting for the data.

Once a model was selected, we examined the posterior probabilities for each trajectory group

to ensure all groups provided evidence for adequate model fitting. A general rule required an acceptable model to have a minimum average posterior probability of 0.70 for all trajectories(4). In this study, average posterior probabilities for all trajectories were at least 0.75 (**Supplemental Table 3**)

References

1. Ye M, Robson PJ, Eurich DT, Vena JE, Xu JY, Johnson JA. Changes in body mass index and incidence of diabetes: A longitudinal study of Alberta's Tomorrow Project Cohort. Preventive medicine. 2018;106:157-63.
2. Wang M, Yi Y, Roebothan B, Colbourne J, Maddalena V, Wang PP, et al. Body Mass Index Trajectories among Middle-Aged and Elderly Canadians and Associated Health Outcomes. J Environ Public Health. 2016;2016:7014857.
3. Nagin DS. Analyzing developmental trajectories: a semiparametric, group-based approach. Psychological methods. 1999;4(2):139.
4. Nagin DS, NAGIN D. Group-based modeling of development: Harvard University Press; 2005.
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Supplemental Table 2. Tabulated Bayesian Information Criterion(BIC)

Number of Groups	BIC	Group membership probability (%)				
		Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**
2	-122975.01	55.71%	44.28%			
3	-118354.21	23.59%	55.57%	20.83%		
4	-115974.84	8.71%	40.24%	39.25%	11.79%	
5	-114586.35	2.09%	29.51%	51.37%	14.90%	2.12%

Supplemental Table 3. Parameters estimated for BMI trajectory change pattern

BMI trajectory change pattern	Parameter Estimate (SE)*				Group membership probability (%)	Average posterior probability (%)
	Intercept term	Linear term	Quadratic term	Cubic term		
Loss	**-0.087 (0.036)**	**-0.821 (0.029)**	**0.074 (4×10^{-3})**	**-0.002 (1×10^{-4})**	8.71	84.6
Stable	-0.012 (0.016)	-0.007 (0.011)	-5.32×10^{-5} (0.001)	4.43×10^{-5} (5×10^{-5})	40.24	76.5
Moderate gain	7.75×10^{-5} (0.017)	**0.297 (0.012)**	**-0.013 (0.002)**	**3.06×10^{-4} (5×10^{-5})**	39.25	75.8
Substantial gain	**0.033 (0.016)**	**0.936 (0.023)**	**-0.064 (0.003)**	**0.002 (1×10^{-4})**	11.79	87.1

*Parameter estimate presented the shape of each pattern of trajectory over time. Intercept term interpreted as the expected level of change of BMI in kg/m2 at the first year of follow-up. Linear term interpreted as the linear slope of change of BMI by follow-up year. Quadratic term interpreted as the quadratic slope and cubic term interpreted as the cubic slope. The significant parameter ($P<0.05$) is highlighted in bold characters.

Supplemental Table 4. The hazard of diabetes in each wave surveys of CHNS from 1991 to 2011 in final analytic sample.

	1991*	1993	1997	2000	2004	2006	2009	2011	Total
Participants	448	1374	621	1076	716	1415	1207	7328	13737
Self-reported diabetes	0	0	11	26	16	62	53	330	498
Death	0	267	172	247	129	161	88	7	1071
Hazard of self-reported diabetes	.	.	1.8%	2.4%	2.2%	4.4%	4.3%	4.5%	3.7%

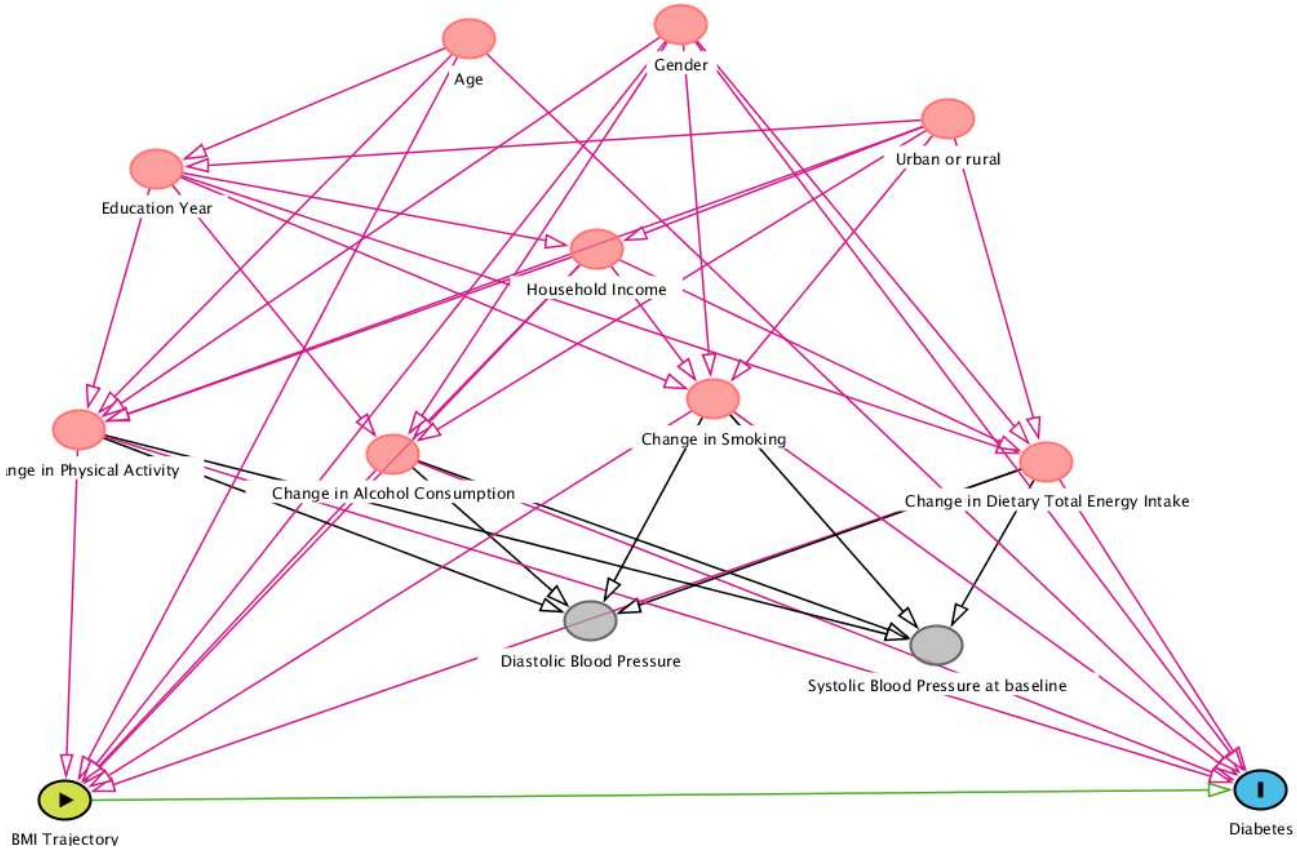
The hazard of diabetes in 1991 and 1993 was missing as self-reported diabetes were first collected in 1997.

Supplemental Table 5. Sensitivity analysis of the associations between different patterns of BMI trajectories and the hazard of T2DM with missing data

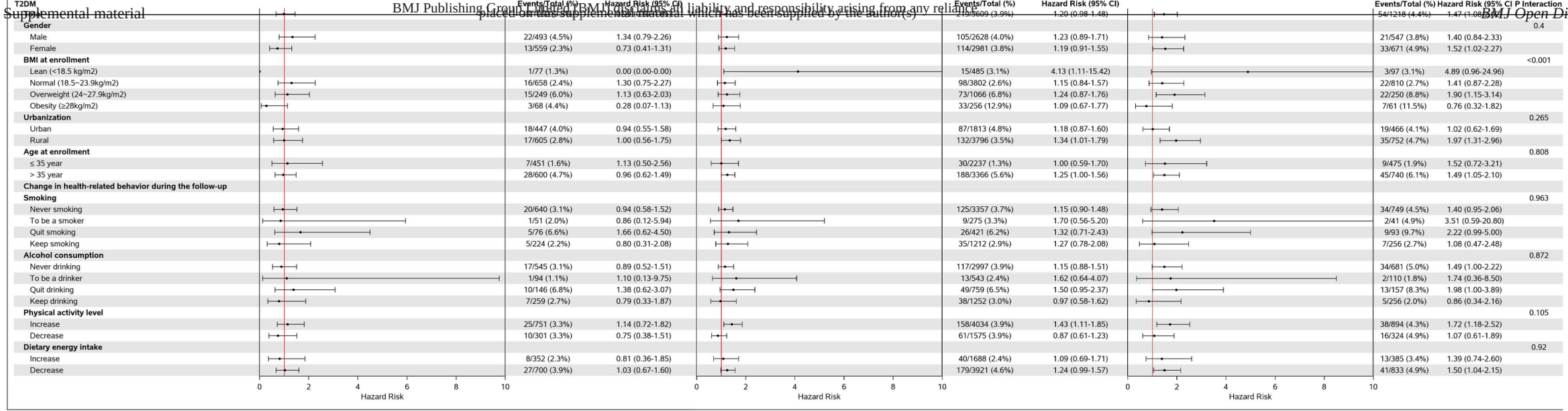
BMI trajectory change pattern	Multiple Imputation with MAR assumption		Multiple Imputation with MNAR assumption	
	HR (95% CI)	***P***	***HR (95% CI)***	***P***
Loss	0.99 (0.69~1.42)	0.973	1.05 (0.74~0.74)	0.77
Stable	Reference		Reference	
Moderate gain	1.18 (0.97~1.43)	0.099	1.17 (0.96~1.42)	0.110
Substantial gain	1.33 (0.99~1.80)	0.062	**1.36 (1.01~1.85)**	**0.044**

CI, confidence interval; HR, hazard ratio; MAR, Missing as random; MNAR, Missing not as random

Supplemental Figure 1. the directed acyclic graph among the potential covariates in the relationship between the pattern of longitudinal trajectories of BMI change and the hazard of Type 2 Diabetes



Supplemental Figure 2. Subgroup analysis for the associations between different patterns of BMI trajectories and the risk of type 2 diabetes.


T2DM
Events/Total (%)
Hazard Risk (95% CI)
Events/Total (%)
Hazard Risk (95% CI)
Events/Total (%)
Hazard Risk (95% CI)
P Interaction
54/1218 (4.4%) 1.47 (1.08-1.99) 0.014
Gender 0.4
Male 22/493 (4.5%) 1.34 (0.79-2.26) 105/2628 (4.0%) 1.23 (0.89-1.71) 21/547 (3.8%) 1.40 (0.84-2.33)
Female 13/559 (2.3%) 0.73 (0.41-1.31) 114/2981 (3.8%) 1.19 (0.91-1.55) 33/671 (4.9%) 1.52 (1.02-2.27)
BMI at enrollment <0.001
Lean (<18.5 kg/m2) 1/77 (1.3%) 0.00 (0.00-0.00) 15/485 (3.1%) 4.13 (1.11-15.42) 3/97 (3.1%) 4.89 (0.96-24.96)
Normal (18.5~23.9kg/m2) 16/658 (2.4%) 1.30 (0.75-2.27) 98/3802 (2.6%) 1.15 (0.84-1.57) 22/810 (2.7%) 1.41 (0.87-2.28)
Overweight (24~27.9kg/m2) 15/249 (6.0%) 1.13 (0.63-2.03) 73/1066 (6.8%) 1.24 (0.87-1.76) 22/250 (8.8%) 1.90 (1.15-3.14)
Obesity (≥28kg/m2) 3/68 (4.4%) 0.28 (0.07-1.13) 33/256 (12.9%) 1.09 (0.67-1.77) 7/61 (11.5%) 0.76 (0.32-1.82)
Urbanization 0.265
Urban 18/447 (4.0%) 0.94 (0.55-1.58) 87/1813 (4.8%) 1.18 (0.87-1.60) 19/466 (4.1%) 1.02 (0.62-1.69)
Rural 17/605 (2.8%) 1.00 (0.56-1.75) 132/3796 (3.5%) 1.34 (1.01-1.79) 35/752 (4.7%) 1.97 (1.31-2.96)
Age at enrollment 0.808
≤ 35 year 7/451 (1.6%) 1.13 (0.50-2.56) 30/2237 (1.3%) 1.00 (0.59-1.70) 9/475 (1.9%) 1.52 (0.72-3.21)
> 35 year 28/600 (4.7%) 0.96 (0.62-1.49) 188/3366 (5.6%) 1.25 (1.00-1.56) 45/740 (6.1%) 1.49 (1.05-2.10)
Change in health-related behavior during the follow-up
Smoking 0.963
Never smoking 20/640 (3.1%) 0.94 (0.58-1.52) 125/3357 (3.7%) 1.15 (0.90-1.48) 34/749 (4.5%) 1.40 (0.95-2.06)
To be a smoker 1/51 (2.0%) 0.86 (0.12-5.94) 9/275 (3.3%) 1.70 (0.56-5.20) 2/41 (4.9%) 3.51 (0.59-20.80)
Quit smoking 5/76 (6.6%) 1.66 (0.62-4.50) 26/421 (6.2%) 1.32 (0.71-2.43) 9/93 (9.7%) 2.22 (0.99-5.00)
Keep smoking 5/224 (2.2%) 0.80 (0.31-2.08) 35/1212 (2.9%) 1.27 (0.78-2.08) 7/256 (2.7%) 1.08 (0.47-2.48)
Alcohol consumption 0.872
Never drinking 17/545 (3.1%) 0.89 (0.52-1.51) 117/2997 (3.9%) 1.15 (0.88-1.51) 34/681 (5.0%) 1.49 (1.00-2.22)
To be a drinker 1/94 (1.1%) 1.10 (0.13-9.75) 13/543 (2.4%) 1.62 (0.64-4.07) 2/110 (1.8%) 1.74 (0.36-8.50)
Quit drinking 10/146 (6.8%) 1.38 (0.62-3.07) 49/759 (6.5%) 1.50 (0.95-2.37) 13/157 (8.3%) 1.98 (1.00-3.89)
Keep drinking 7/259 (2.7%) 0.79 (0.33-1.87) 38/1252 (3.0%) 0.97 (0.58-1.62) 5/256 (2.0%) 0.86 (0.34-2.16)
Physical activity level 0.105
Increase 25/751 (3.3%) 1.14 (0.72-1.82) 158/4034 (3.9%) 1.43 (1.11-1.85) 38/894 (4.3%) 1.72 (1.18-2.52)
Decrease 10/301 (3.3%) 0.75 (0.38-1.51) 61/1575 (3.9%) 0.87 (0.61-1.23) 16/324 (4.9%) 1.07 (0.61-1.89)
Dietary energy intake 0.92
Increase 8/352 (2.3%) 0.81 (0.36-1.85) 40/1688 (2.4%) 1.09 (0.69-1.71) 13/385 (3.4%) 1.39 (0.74-2.60)
Decrease 27/700 (3.9%) 1.03 (0.67-1.60) 179/3921 (4.6%) 1.24 (0.99-1.57) 41/833 (4.9%) 1.50 (1.04-2.15)
0 2 4 6 8 10
Hazard Risk
0 2 4 6 8 10
Hazard Risk
0 2 4 6 8 10
Hazard Risk