Social Determinants of Health Are Associated with Modifiable Risk Factors for Cardiovascular Disease and Vascular Function in Pediatric Type 1 Diabetes

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Objective To evaluate the relationship between social determinants of health (SDH) and cardiovascular disease (CVD) risk factors as well as a measure of arterial stiffness in adolescents with type 1 diabetes (T1D).

Study design SDH were measured with the validated Ontario Marginalization Index, derived from deidentified postal code data and stratified by quintile (first = least deprived; fifth = most deprived). SDH dimensions included material deprivation; ethnic concentration; and measures of dependency and residential instability. Metabolic control (hemoglobin A1c), cardiovascular risk metrics, and pulse wave velocity, as a measure of arterial stiffness, were related to SDH. Data were evaluated from a cohort of Canadian adolescents within the Adolescent Diabetes Cardiorenal Intervention Trial, a T1D clinical trial

Results A total of 704 participants were evaluated, and significant differences in hemoglobin A1c were evident at the extremes of material deprivation (8.4% vs 9.1% for least vs most deprived, $P < .01$). CVD risk factors were analyzed in 199 participants, with the most deprived reporting significantly less exercise ($P = .004$) and increased rates of smoking ($P = .008$). Increased material deprivation was associated with fewer metrics of "ideal" cardiovascular health attained. Arterial stiffness, as measured by pulse wave velocity, was associated positively with age, body mass index z score, and material deprivation.

Conclusion Increased material deprivation was associated with poorer glycemic control. Modifiable, lifestyle-related risk factors for CVD and early arterial wall change are associated with SDH and represent a target for clinical intervention to reduce future CVD burden in adolescents with T1D. *(J Pediatr 2016;177:167-72).*

The social determinants of health (SDH) encompass "the circumstances in which people are born, grow up, live, work, and age."[1] These environmental factors have a significant impact on the health outcomes of many chronic diseases. Identifying the nonbiological factors that influence the development and progression of diabetes complications is gaining widespread attention.[2]

Cardiovascular disease (CVD) is a major cause of morbidity and mortality in type 1 diabetes (T1D).[3] The emergence of CVD risk factors, such as dyslipidemia and hypertension, in this population merits attention towards risk factor reduction. Important modifiable risk factors for CVD, including smoking, physical activity, sedentary activity, and obesity, are rooted in pediatric behavior and may be critical areas for targeted intervention.[4-6] Recent evidence has linked low socioeconomic status with increased risk of mortality during adulthood in patients with childhood-onset diabetes[7]; however, there are limited data in the pediatric population relating SDH to CVD risk accumulation in patients with diabetes. Data in the healthy-adolescent population suggest there is early accumulation of CVD risk factors,[5] albeit at likely lower incidence rates and without the added burden of comorbid diabetes.[8] Given the increased baseline risk of CVD burden in the diabetes population, there is great impetus for clinicians to identify and mitigate modifiable CVD risk factors in childhood and adolescence.

ACR	Albumin-to-creatinine ratio
AdDIT	Adolescent Diabetes Cardiorenal Intervention Trial
BMI	Body mass index
CVD	Cardiovascular disease
HbA1c	Hemoglobin A1c
ICH	"Ideal" cardiovascular health
ISPAD	International Society for Pediatric and Adolescent Diabetes
LDL	low-density lipoprotein
ON-Marg	Ontario Marginalization Index
PWV	Pulse wave velocity
Q1	First quintile
Q2	Second quintile
Q4	Fourth quintile
Q5	Fifth quintile
SDH	Social determinants of health
T1D	Type 1 diabetes

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Table I. ISPAD cardiovascular metrics attained in relation to SDH (material deprivation) in the Canadian AdDIT observational arm study participants

Criteria	ISPAD cardiovascular metrics	Metrics attained n = 199	MD—Q1/Q2 n = 121	MD—Q4/Q5 n = 44	*P*
HbA1c	<7.5% (all ages)	35 (15%)	23 (19%)	5 (11.4%)	.25
LDL	<2.6 mmol/L (<100.5 mg/dL)	136 (68%)	79 (65.3%)	32 (72.7%)	.36
HDL	>1.1 mmol/L (<42.5 mg/dL)	188 (94%)	114 (94.2%)	41 (93.2%)	.73
Triglycerides	<1.7 mmol/L (<150.6 mg/dL)	194 (97%)	120 (99.2%)	42 (97.7%)	.46
Blood pressure	SBP <130 and DBP <80 for adolescents	178 (89%)	109 (90.1%)	40 (90.9%)	.99
BMI	<95% percentile for age	169 (85%)	106 (87.6%)	37 (84.1%)	.56
ACR	<2.5-25 (M); <3.5-25 (F), mg/mmol <22.1-221 (M); <31-221 (F), mg/g	187 (94%)	116 (95.9%)	40 (90.9%)	.25
Physical activity	>1 hour per day, 3 days per week*	160 (80%)	107 (89.2%)	31 (70.5%)	**<.01**
Sedentary activity	<2 hours per day	75 (38%)	51 (42.2%)	12 (27.3%)	.07
Smoking	None (never smoked)	181 (91%)	115 (96.6%)	36 (83.7%)	**<.01**
Total score	Of 10 target metrics	7.55 (1.26 SDS)	7.8 (median8)	7.3 (median7)	**<.01**

DBP, diastolic blood pressure; *F*, female; *HDL*, high-density lipoprotein; *M*, male; *MD*, material deprivation; *SBP*, systolic blood pressure.
Bold values are statistically significant.
*ISPAD target: >1 hour moderate physical activity per day, 7 days per week.

Through the evaluation of a well-characterized cohort of participants in the Canadian arm of the Adolescent Diabetes Cardiorenal Intervention Trial (AdDIT), the objectives of this study were to explore the relationship among (1) SDH and glycemic control (hemoglobin A1c [HbA1c]); (2) SDH and risk factors for CVD, including metrics of "ideal" cardiovascular health (ICH); and (3) SDH and pulse wave velocity (PWV) as a measure of arterial stiffness reflecting early vascular dysfunction.

Methods

Data were gathered from baseline clinical assessments from an existing cohort study of adolescents with T1D. Participants were recruited from October 2007 to November 2012 from The Hospital for Sick Children (a pediatric tertiary center in Toronto, Canada) and from regional, affiliated diabetes centers as part of a well-characterized participant cohort enrolled within the Canadian arm of AdDIT (ClinicalTrials.gov: NCT01581476).[9] Only baseline data were used from subjects in this report, and results of the experimental arm of the global AdDIT trial are expected at a later date.

Participants aged 10-16 years with T1D ≥1 year were eligible for AdDIT screening. The diagnosis of T1D was based on the criteria of the American Diabetes Association.[10] Enrollment in the AdDIT study was based on tertile stratification of urine albumin-to-creatinine ratio (ACR) measurements (lower and middle tertiles were eligible for observational arm enrollment; those within the highest tertile were eligible for experimental arm) during the screen-in recruitment phase. Exclusion criteria included non-T1D; personal or family history of severe hyperlipidemia; established hypertension not related to diabetic nephropathy; previous exposure to statins or angiotensin-converting enzyme inhibitors; proliferative retinopathy; or certain medical comorbidities. All participants were covered under the provincial health care plan. Approval for this ancillary study was obtained from our institutional research ethics board.

Deidentified participant data of the Canadian AdDIT study arm were linked to publically available data from the Ontario Marginalization Index (ON-Marg), which measures material deprivation, ethnic concentration, dependency, and residential instability.[11] Participant-level data collected included postal code, sex, age, and HbA1c (at study recruitment). These data enabled validation of SDH distribution through the recruitment process and for the confirmation of the SDH-HbA1c relationships that have been described previously in our population[12] with the use of similar measures (total cohort analyzed, n = 704 from: all eligible for study entry, n = 717; missing HbA1C or deprivation quintile, n = 13).

The ON-Marg, a well-studied and validated measure used in Canadian cohorts, is composed of specific criteria which inform 4 composite dimensions: material deprivation (a proxy for socioeconomic status, education, and single parent families); ethnic concentration (a proxy for recent immigration and visible minorities); dependency (a proxy for a population's workforce eligibility); and residential instability (a proxy for home security, ownership, and occupancy). ON-Marg reports data in quintiles representing 20% of the reference population (first quintile or Q1 = least deprived; fifth quintile or Q5 = most deprived). Quintile extremes may imply either positive, negative, or neutral relationships on health outcomes. Participant dissemination areas, which represent the smallest area of census-specific information from which unique SDH data exist, were determined by participant postal codes and linked to each of the 4 ON-Marg dimensions to generate quintile distributions. Previously published data showed that our clinic population mirrored that of the background city population across all SDH; furthermore, our clinic records demonstrate no significant difference in clinic attendance across SDH dimensions.[12]

Cardiovascular risk metrics, based on the 2014 International Society for Pediatric and Adolescent Diabetes (ISPAD) clinical practice guidelines for microvascular and microvascular complications[13] (**Table I**), were reported for all participants within the Canadian observational arm of AdDIT (n = 199). These data included insulin regimen (pump or in-