Social determinants of health and interruption in treatment outcomes within Haiti's electronic medical record system for people living with HIV

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Abstract

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Global Health

Haiti has made significant progress in reducing the national burden of HIV, however patient retention in care and treatment persists as a key challenge. Low-resource settings are increasingly using electronic medical records (EMRs) to strengthen their health information systems and improve patient outcomes. Social determinants of health (SDOH) like employment, education, food insecurity, and stigma are documented risk factors for poor HIV treatment outcomes but are often not captured or collected in structured formats in EMRs. We conducted an exploratory study assessing the types and completeness of SDOH data in Haiti's EMR and investigated associations with interruption in treatment (IIT) at 6- and 12-months post-antiretroviral therapy (ART) initiation. We used patient-level data from 51 clinic sites. Eligible patients were adults with a documented ART start date between July 2016 and January 2022. SDOH variables were

categorized by the following six domains: 1) economic stability, 2) education, 3) food, 4) social and community context, 5) physical and built environment, and 6) health and clinical care. A mixed effects logistic regression model was fit to assess the relationship between independent SDOH variables and IIT. We found a lack of variables related to physical and built environment, food, education, and economic stability in Haiti's EMR. Data completion varied by variable type for several SDOH variables available for analysis. Approximately one in ten patients had IIT at 6 months and nearly one in five had IIT at 12 months. Documentation of the HIV status of other household members, a possible marker for social context, was associated with a lower likelihood of IIT. There were several SDOH reasons associated with higher risk of IIT, including travel and lack of food. This analysis highlights a missed opportunity to collect individual-level SDOH data within Haiti's EMR and identify clients at greatest risk of IIT who could benefit from interventions to provide enhanced support for ART retention in care.

Introduction

The Caribbean region has the highest prevalence of HIV outside of Sub-Saharan Africa, with Haiti facing the highest country-level burden at a prevalence of 2% among people aged 15-49 years.[1–3] HIV/AIDS is the underlying cause of about 6% of deaths in Haiti.[4] More than half of Haiti's 11.4 million people live below the poverty line designation for lower-middle income countries of 3.2 USD per day, and the country faces substantial inequality with the top one-fifth of the population holding roughly two-thirds of the country's total wealth as compared to the bottom one-fifth holding less than one percent.[5] Severe social, economic, environmental, and political crises have escalated since July 2021 and led to increasing levels of civil unrest and violence, disrupting access and availability of health and social services.[5]

Haiti has made significant progress in reducing the national burden of HIV: the prevalence of people living with HIV (PLWH) decreased from 6.2% to 2% between 1993 and 2017.[6] The *Ministère de la Santé Publique et de la Population* (Haitian Ministry of Health, MSPP) continues to make strides in increasing the number of people on antiretroviral therapy (ART) following the adoption of the World Health Organization's Test and Start policy in July 2016, which recommends that asymptomatic patients initiate ART within seven days of HIV diagnosis, if not on the same-day.[7–9] However, patient retention in care persists as a key challenge.[6,10–12] Research in Haiti has identified multiple risk factors for poor retention including being younger in age, living far from the health facility, high transportation costs to the health facility, having no known household members living with HIV, starting ART during pregnancy or during the postpartum period, not receiving pre-ART counseling, experiencing depression, having an inability to meet basic needs, and experiencing high levels of perceived stigma.[12–16]

In December 2021, the United States President's Emergency Plan for AIDS Relief (PEPFAR) program, which funds almost 80% of Haiti's current HIV response, reported more people falling out of routine treatment than those maintained on treatment for the first time since 2019.[2] Optimal HIV treatment requires consistent daily antiretroviral (ARV) adherence in order to achieve sufficient viral suppression in a patient, and low levels of adherence are associated with a higher potential for the development of drug resistance, higher rates of mortality, and higher probability of onward transmission due to higher viral load.[13,14,17,18]

Low-resource setting countries are increasingly using electronic medical records (EMRs) to strengthen their health information systems by documenting patient-level data in structured formats to improve access to information, increase efficiency, and improve quality of care.[19–25] Haiti has a robust EMR system named iSantéPlus, and there is potential to better leverage routinely collected data for identification and targeted support of patients at highest risk of poor HIV outcomes.

Research in low-and-middle-income countries (LMICs) has identified socioeconomic variables such as income, employment, education, and food security, as well as psychosocial variables such as stigma, social support, and social position, as risk factors for HIV treatment interruption and adherence.[26–30] These types of variables are generally considered to fall under the umbrella of social determinants of health (SDOH). One of the main limitations of research using routine data from iSantéPlus has been the inability to test associations between key psychosocial and socioeconomic patient characteristics and treatment outcomes because these variables are either not captured within the EMR, or they are captured but collected in unstructured formats or with

low completeness of data.[12,17,31] Assessments of data quality in EMRs across LMICs have mostly focused on key clinical variables rather than SDOH variables, and literature on the integration of SDOH in EMRs and the potential for using such data to predict patient outcomes is limited primarily to high-income, Global North countries.[32–34]

Haiti's national ART program has accelerated its use of differentiated service delivery (DSD) in recent years. DSD is based on the recognition that a one-size-fits-all, clinical approach to HIV does not address the needs of all populations. DSD uses a person-centered approach to simplify and optimize service access while also enhancing patient outcomes.[35,36] In Haiti, this includes multi-month dispensing, community-based ART delivery and the use of community drug dispensation points.[2] Exploring a comprehensive set of factors, including SDOH, that predict ART retention and adherence outcomes could help in early identification of patients for whom a DSD model of care could be beneficial. A collaboration between the MSPP, local nongovernmental organization (NGO) *Centre Haïtien pour le Renforcement du Système de Santé* (CHARESS), and the University of Washington's International Training and Education Center for Health (I-TECH) has explored the use of EMR data to predict ART patients at risk of poor health outcomes and provide clinical decision support (CDS) to alert providers of patients at highest risk of poor outcomes, so they can offer intensified counseling and supportive services.[11] Future research aims to enhance the use of prediction models with structured socioeconomic and psychosocial data. An exploratory study assessing the types of SDOH data currently available in Haiti's EMR and their associations with HIV treatment outcomes is therefore highly beneficial and serves to inform future research. This analysis had the following aims:

Aim 1: Identify and categorize available variables from registration and adherence visits within Haiti's iSantéPlus electronic medical record system from July 2016-July 2022 by social determinants of health (SDOH) domain.

Aim 2: Assess data completion of key variables within the iSantéPlus electronic medical record system at the patient-level.

Aim 3: Explore the association between key SDOH variables and interruption in treatment (IIT) outcomes at 6- and 12-months post-ART initiation among PLWH.

Methods

Haiti's national HIV program and EMR systems

Haiti's EMR system was developed in 2005 in collaboration between MSPP, US Centers for Disease Control, and the International Training and Education Center for Health (I-TECH) at the University of Washington.[21] iSantéPlus collects longitudinal data for PLWH and operates at almost 90% of health facilities providing HIV care and treatment, covering roughly two-thirds of Haiti's ART patients.[10–12] It includes forms for HIV clinical care, laboratory work, pharmacy services, ART adherence, counseling, referrals, and home visits, and its user processes have shifted over the years from retrospective data entry via paper forms to point-of-care data collection.[17]

Study design

For aim 1, we carried out a desk review of iSantéPlus data collection forms and system documentation to categorize SDOH elements captured within the system's current data model. Referencing research by the US-based Social Interventions Research and Evaluation Network

(SIREN), data variables were categorized by the following six domains: 1) economic stability, 2) education, 3) food, 4) social and community context, 5) physical and built environment, and 6) health and clinical care.[37] For aim 2, we assessed the completion of adherence and household composition variables among eligible patients using patient-level EMR data. For aim 3, we conducted an exploratory analysis of retrospective observational EMR data to assess the relationship between SDOH data in the EMR and interruption in treatment (IIT).

EMR data was extracted as separate data files which correspond to various source forms. Patient registration data containing information on demographic variables such as age, sex, marital status, health facility, and geographic department was merged with data from household composition and adherence forms. The dataset of ART pharmacy dispensing records was used to determine patients' ART start dates and instances of IIT. Duplicate patient IDs were deleted to ensure unique observations were assessed.

Participants

This analysis used patient-level EMR data extracted from iSantéPlus in December 2022 for 81 clinic sites. These sites were chosen based on their migration to iSantéPlus, an OpenMRS platform that uploads data to a central server and allows for the pull of de-identified data by CHARESS.[38] We excluded sites with greater than 20% of all forms entered more than 90 days after the encounter date, to increase the likelihood that the site's data could be trusted as representing an accurate status of patient data. We also excluded sites with fewer than five ART pharmacy prescription forms per patient, as this could be an indicator of data quality or data entry issues at the site, rather than an accurate representation of ART prescription encounters.

Finally, prison sites and sites with a patient volume of fewer than 50 ART patients were excluded from the analysis, leaving a total of 51 sites with 79,769 unique ART patients.

Eligible patients for our analysis were those from the included clinical sites with a documented ART start date between July 1, 2016 and January 1, 2022. These cut-off dates were chosen to control for potential changes in treatment patterns following the national adoption of the HIV Test and Start policy and to allow sufficient time to observe the outcome of IIT at 6 and 12 months. Haiti's adult HIV care forms are for patients age 15 and up, therefore all patients included were 15 years or older. Patients with no attended pharmacy visits within 12 months of initiating ART were excluded. Additionally, eligible patients had to have at least one documented adherence visit date within 6 months of initiating ART- regardless of whether the variables for the adherence form were filled out. Finally, patients without complete demographic data (age, sex, and marital status) were excluded.

Study variables

Independent variables included in this study were chosen based on availability and an understanding of potential predictors of interruption in treatment based on existing research. These included demographic variables of sex, age, marital status, and geographic department, a self-reported adherence measure of number of missed ART doses in the past four days, select SDOH variables, and data completion variables for adherence and household data.

The age of patients was categorized following the standard age groups used in PEPFAR reporting: 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, and 50+ years. Marital status

categories included cohabitating, married, single, widowed, separated, and unknown. Geographic departments include Artibonite, Grande-anse, Nippes, Nord, Nord-est, Nord-ouest, Ouest, Sud, and Sud-est. Missed ART doses were categorized as having none or at least one missed dose reported. Each reason for missing an ART dose was set-up as binary variable and included: ART medication unavailable at clinic, patient completed (i.e., used up) all medication, patient lost medication, patient uncomfortable taking medication in the presence of others, patient forgot to take medication, patient has traveled, patient did not want the medication, patient had a lack of food, patient was imprisoned, patient felt well enough, other reason, and no reason reported. Adherence form completion was categorized as complete or incomplete and household composition was categorized as "HIV status of other household members documented" or "HIV status of other household members not documented."

The outcome variable was interruption in treatment (IIT), defined as "no clinical contact for 28 days after the last scheduled appointment or expected clinical contact", and served as a proxy indicator for patient retention in care in this analysis.[39] This was measured at the patient-level as a binary outcome at 6 months and 12 months post-ART start date. The reference visits upon which the IIT outcome variable was based were determined using the patient's attended pharmacy visit closest to but not past their 6- and 12-month anniversary date, respectively. A patient was considered interrupted in treatment if the date 28 days after their expected pharmacy return following the reference visit fell before the 6- and 12-month ART anniversary date.

Data analysis

Quantitative data analysis was conducted in R Studio software (version 4.1.1). We carried out descriptive analysis on the demographics of the eligible patient population and determined prevalence of IIT at 6 months and 12 months overall and within subgroups of each independent variable. We analyzed the frequency distribution of reported reasons among the subset of patients who missed an ART dose. We assessed the proportion of patients with complete adherence form documentation and household composition documentation.

A mixed effects logistic regression model was fit to assess the relationship between independent SDOH variables and IIT at 6 months and 12 months. We accounted for clustering at the facility level using random effects. Variables associated with IIT in initial bivariate models ($p < 0.1$) were included in the multivariable model. Fitting of the final model was done using stepwise backward elimination, with variables kept if they exhibited a significant association alongside additional adjustment variables ($p < 0.05$).

Ethical approval

This study's objectives and methods involved secondary use of de-identified data. The research fell within an existing protocol that was exempted from human subjects review by the UW Human Subjects Division (HSD) (STUDY00016591: Patient Risk Profiles for Interruption in Treatment (IIT) among People Living with HIV (PLWH) in Haiti: Leveraging Health Information Systems and Prediction Models to Identify Patients at High Risk). The research was also reviewed and approved by the Haiti Ministry of Public Health and Population's National Bioethics Committee (Ref # 2223-26).

Results

Categorization and distribution of variables by SDOH domain

Table 1a shows the definition of the six SDOH domains used in this paper, adapted from a systematic review of social risk screening tools in the United States conducted by SIREN.[37] It also provides a breakdown of constructs related to each domain, which were used to categorize an overall set of 53 variables from question and response categories across three of the adult HIV forms: adherence form, household counseling form, and home visit form. Although some variables could fit in more than one domain, for the purpose of this analysis we chose one primary SDOH domain for each variable. Due to challenges with data extraction and unstructured variable formats, only 17 out of 53 variables were available for full analysis. Table 1b shows the categorization of these variables. Supplemental Table 1c provides the description and categorization of the remaining variables.

Our categorization process found that the social and community context domain contained the largest number of variables, with 21 out of 53. The health and clinical care and physical and built environment domains followed with nine and seven variables, respectively. Four variables fell within the education domain and three within the food domain. We did not find any variables within the economic domain. Nine variables did not fall into any SDOH domain due to having a direct clinical nature or because the variable description was too vague to be categorized appropriately.

Demographic characteristics, data completeness, self-reported adherence, and household composition

21041 patients met inclusion criteria and were included in the final analysis. The sample was 62.8% female and the median age was 40 years (IQR 33-49). Most patients (75.5%) had an unknown marital status and 64.1% initiated ART at clinics in the Ouest and Nord geographic departments. 90.2% of patients had a fully completed adherence form and 32.6% had fully completed household composition data.

34.0% of patients (n=7160) had an adherence form with one or more missed doses reported and 66.0% (n=13881) had an adherence form without any missed doses reported. Figure 1 shows the distribution of reported reasons for missing a dose. The top reported reason for missing a dose was that the patient had completed all their medication (n=2879). 31.6% (n=2266) of patients who missed a dose had no reason documented. Very few patients cited imprisonment or unavailability of medicine at the clinic as reasons for missing a dose, so these two reasons were not included in subsequent prevalence and regression analysis. Among the subset of total patients with complete household composition data (n=6932), 88.5% reported having no household members known to be living with HIV and 11.5% reported having one or more household members known to be living with HIV.

Table 1a SDOH domains and constructs[40]

Domain	**Social and Community Context**	**Physical and Built Environment**	**Health and Clinical Care**	**Food**	**Education**	**Economic Stability**
Definition	The immediate social setting in which people live or in which something happens or develops. It includes the culture that an individual was educated or lives in, and the institutions with whom they interact.	The land, air, water, plants, animals, buildings, other infrastructure, and all natural resources that provide our basic needs and opportunities for social and economic development.	The health and wellbeing of individuals and whether they have access to quality clinical care.	Agricultural production, access to and distribution of food, dietary patterns, diversity of food available, home production of food, food safety, and foodborne illness hazards.	The degree to which an individual has completed various levels of schooling or formal education. This could include public, private, or technical school or an extracurricular course or apprenticeship.	Any measure of a person's finances and the ability or inability of an individual or family to afford basic life necessities.
Constructs	Discrimination, stigma, social integration, social support systems, community engagement, immigration/refugee status	Safety, crime and violence, transportation, environmental conditions, quality of housing, walkability, living conditions	Access to health care, health coverage, provider availability, quality of care, linguistic and cultural competency within healthcare systems	Hunger and food (in)security, access to healthy options	Early childhood education and development, primary, secondary, and higher education, language, literacy, vocational training, health literacy	Employment, income, expenses, debt, medical bills, economic support

Adapted from Henrikson et al. 2019

Table 1b Categorization of available variables by SDOH domain

Source form	Variable Description	Response Options	SDOH construct(s) encompassed	Primary SDOH domain encompassed
Adult adherence form	Reason given for missing an ART dose (check all that apply)	Medication unavailable at the clinic	Access to health care	Health and clinical care
		Completed all medication	Access to health care	Health and clinical care
		Lost medication	Living conditions	Physical and built environment
		Uncomfortable taking medication in front of others	Stigma	Social and community context
		Forgot to take medication	Social support systems	Social and community context
		Has traveled	Access to health care	Health and clinical care
		Did not want medication	Social support systems	Social and community context
		Lack of food	Hunger and food (in)security	Food
		Imprisoned	Living conditions	Physical and built environment
		Felt well enough	Health literacy	Education
		Difficulty swallowing pills	NA	NA
		Side effects	NA	NA
		Felt too sick	NA	NA
		Other	NA	NA
Household counseling form	Number of people in household with known HIV positive status	Numeric entry	Social support systems	Social and community context
	Number of people in household with known HIV negative status	Numeric entry	Social support systems	Social and community context
	Number of people in household with unknown HIV status	Numeric entry	Social support systems	Social and community context

Prevalence of IIT

Table 2 shows the prevalence of IIT at 6 months and 12 months post-ART initiation among our full patient sample. 10.6% (95% CI: 10.2-11.0) and 18.3% (95% CI: 17.8-18.8) of patients were interrupted in treatment at 6 and 12 months. The prevalence of IIT was greater at 12 months compared to 6 months across all explanatory variables, and patterns within categorical variables generally persisted at both time points, as demonstrated in Table 2 and Figure 2. IIT prevalence among patients with documentation of HIV status of other household members was lower than patients without this information documented at both 6 months and 12 months. The lowest prevalence of IIT at 6 months was among individuals whose marital status was cohabitating (3.3%, 95% CI: 2.0-5.5), and the highest prevalence at 6 months was among patients who reported travel as the reason for their missed ART dose (16.1%, 95% CI: 13.2-19.4). At 12 months, the lowest prevalence of IIT was among those who reported feeling well as their reason for their missed dose (10.1%, 95% CI: 8.0-12.6), and the highest levels were among individuals who reported a lack of food as a reason for their missed dose (29.4%, 95% CI: 22.4-37.6) and patients who initiated treatment at a facility in the Sud-est geographic department (29.4%, 95% CI: 23.2-36.5) (Table 2 and Figure 2).

Figure 1 Distribution of self-reported reasons for missing an ART dose

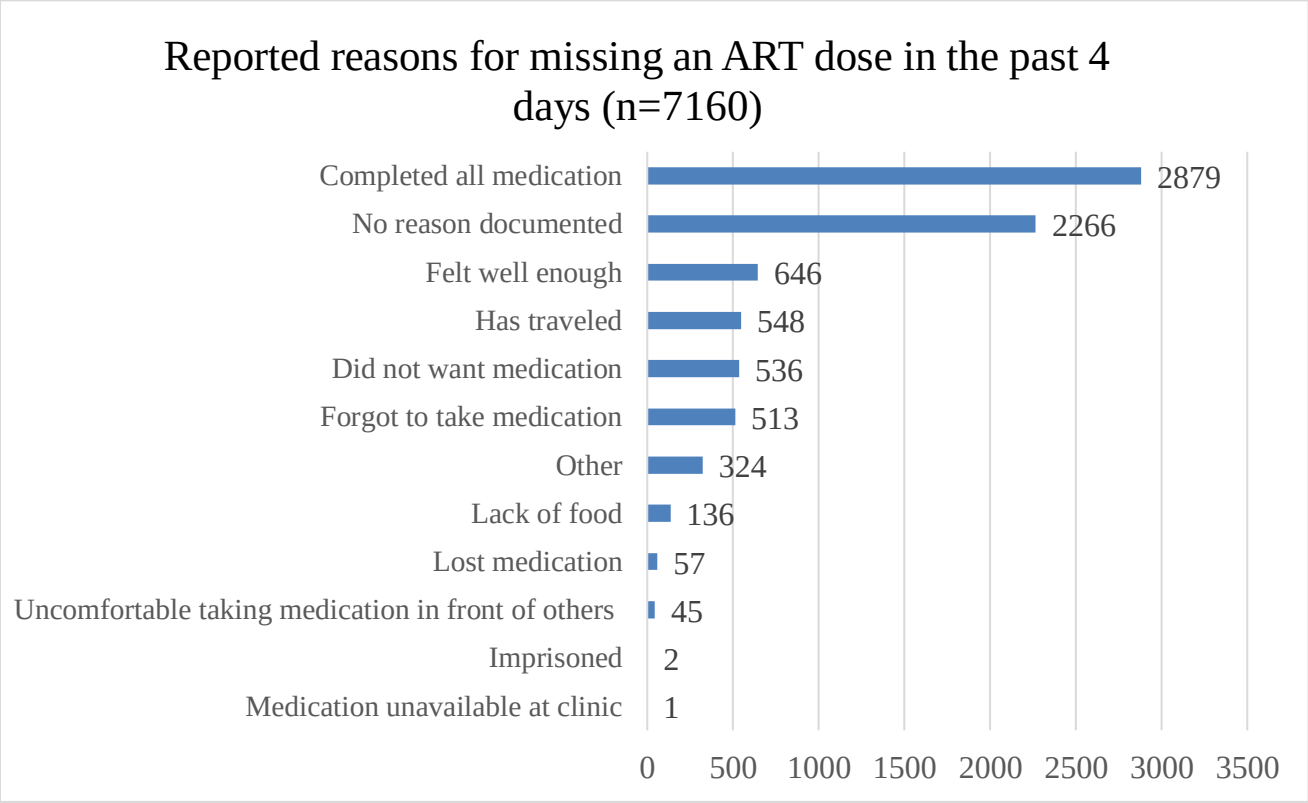


Table 2 Prevalence of PLWH with interruption in treatment (IIT) at 6 months and 12 months post ART-initiation (n=21,041)

	Total	**IIT at 6 months post-ART initiation**		**IIT at 12 months post-ART initiation**	
	n	**n_1[a]**	**% [95% CI][b]**	**n_2[c]**	**% [95% CI][d]**
Overall	21041	2230	10.6% [10.2-11.0]	3852	18.3% [17.8-18.8]
Sex					
Female	13226	1382	10.4% [9.9-10.9%]	2392	18.1% [17.4-18.8]
Male	7815	848	10.9% [10.2-11.6%]	1460	18.7% [17.8-19.6]
Age group (years)					
15-19	201	15	7.5% [4.6-11.9]	34	16.9% [12.3-22.7]
20-24	795	72	9.1% [7.3-11.3]	149	18.7% [16.2-21.6]
25-29	2048	249	12.1% [10.8-13.6]	411	20.1% [18.4-21.9]
30-34	3215	394	12.3% [11.2-13.4]	656	20.4% [19.0-21.8]
35-39	3840	432	11.2% [10.3-12.3]	756	19.7% [18.5-21.0]

40-44	3405	344	10.1% [9.1-11.2]	603	17.7% [16.5-19.0]
45-49	2555	240	9.4% [8.3-10.6]	414	16.2% [14.8-17.7]
50+	4982	484	9.7% [8.9-10.6]	829	16.6% [15.6-17.7]
Marital status					
Cohabitation	425	14	3.3% [2.0-5.5]	68	16.0% [12.8-19.8]
Married	2118	194	9.2% [8.0-10.5]	357	16.9% [15.3-18.5]
Separated	1258	116	9.2% [7.7-10.9]	223	17.7% [15.7-19.9]
Single	190	9	4.7% [2.5-8.8]	40	21.1% [15.9-27.4]
Widowed	1169	106	9.1% [7.6-10.9]	203	17.4% [15.3-19.6]
Unknown	15881	1791	11.3% [10.8-11.8]	2961	18.6% [18.0-19.3]
Department					
Artibonite	2832	260	9.2% [8.2-10.3]	396	14.0% [12.8-15.3]
Grande-anse	1055	129	12.2% [10.4-14.3]	220	20.9% [18.5-23.4]
Nippes	537	52	9.7% [7.5-12.5]	112	20.9% [17.6-24.5]
Nord	5196	579	11.1% [10.3-12.0]	965	18.6% [17.5-19.7]
Nord-est	945	111	11.7% [9.8-13.9]	165	17.5% [15.2-20.0]
Nord-ouest	452	64	14.2 [11.2-17.7]	72	15.9% [12.8-19.6]
Ouest	8294	779	9.4% [8.8-10.0]	1508	18.2% [17.4-19.0]
Sud	1553	232	14.9% [13.3-16.8]	362	23.3% [21.3-25.5]
Sud-est	177	24	13.6% [9.3-19.4]	52	29.4% [23.2-36.5]
HIV status of other household members					
Not documented	14109	1550	11.0% [10.5-11.5]	2666	18.9% [18.3-19.6]
Documented	6932	680	9.8% [9.1-10.5]	1186	17.1% [16.2-18.0]
Adherence form completion					
Incomplete	2050	220	10.7% [9.5-12.1]	389	19.0% [17.3-20.7]
Complete	18991	2010	10.6% [10.2-11.0]	3463	18.2% [17.7-18.8]
Number of missed ART doses in the past 4 days					
No missed doses[e]	13881	1421	10.2% [9.7-10.8]	2281	16.4% [15.8-17.1]
One or more missed doses[f]	7160	809	11.3% [10.6-12.1]	1571	21.9% [21.0-22.9]
Reasons for missing a dose					
Completed all medication	2879	250	8.7% [7.7-9.8]	572	19.9% [18.5-21.4]
No reason documented	2266	277	12.2% [10.9-13.6]	502	22.2% [20.5-23.9]

Felt well enough	646	27	4.2% [2.9-6.0]	65	10.1% [8.0-12.6]
Has traveled	548	88	16.1% [13.2-19.4]	126	23.0% [19.7-26.7]
Did not want medication	536	73	13.6% [11.0-16.8]	129	24.1% [20.6-27.9]
Forgot to take medication	513	45	8.8% [6.6-11.5]	106	20.7% [17.4-24.4]
Other	324	39	12.0% [8.9-16.0]	87	26.9% [22.3-31.9]
Lack of food	136	10	7.4% [4.0-13.0]	40	29.4% [22.4-37.6]
Lost medication	57	3	5.3% [1.8-14.4]	8	14.0% [7.3-23.3]
Uncomfortable taking medication in front of others	45	3	6.7% [2.3-17.9]	12	26.7% [16.0-41.0]
NA (did not miss a dose)	13881	1421	10.2% [9.7-10.8]	2281	16.4% [15.8-17.1]

[a]Number of patients with IIT at 6 months

[b]Percentage calculated as n_1/n

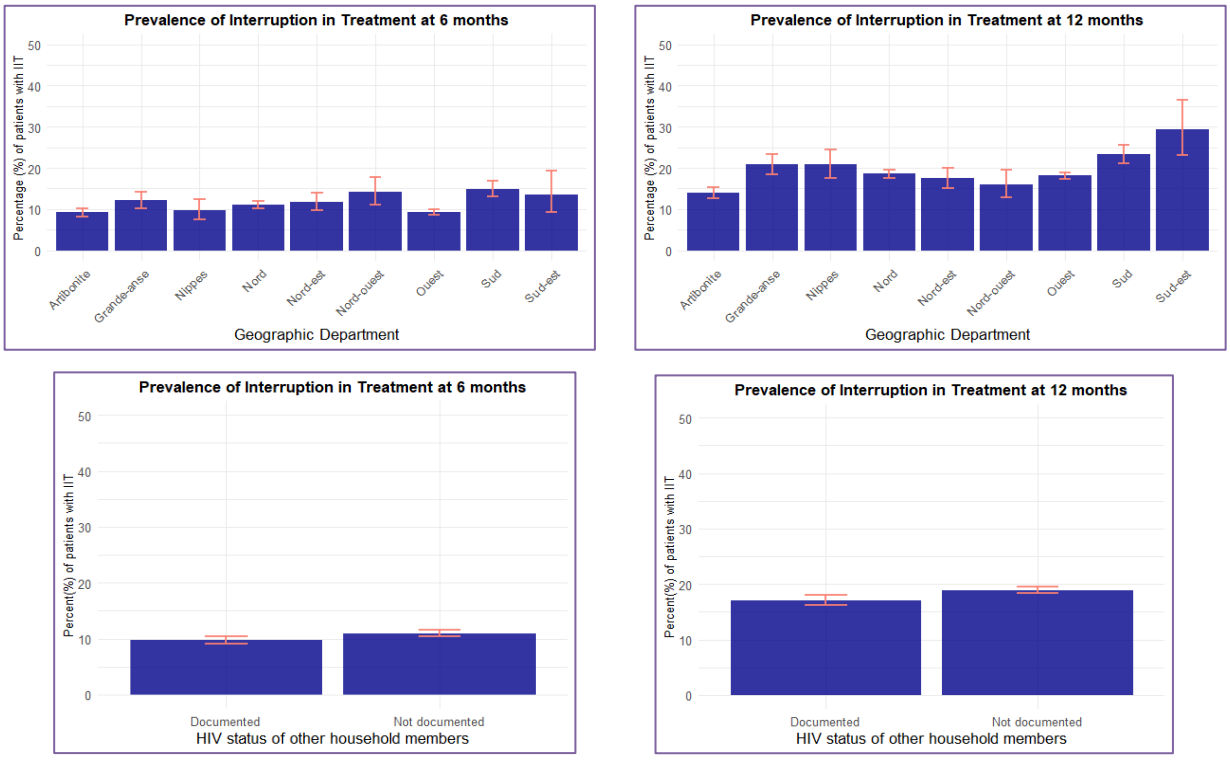
[c]Number of patients with IIT at 12 months

[d]Percentage calculated as n_2/n

[e]Includes patients with null value and no reported reason for missing a dose

[f]Includes patients with null value but at least one reported reason for missing a dose

Figure 2 Prevalence of IIT at 6 and 12 months by geographic department and documentation status of household composition data



Tables 3a and 3b show the logistic regression results in the form of unadjusted and adjusted odds ratios for IIT at 6- and 12-months post-ART initiation, respectively. The results of the adjusted models showed that patients aged 25-29 (aOR = 1.23, 95% CI = 1.04-1.46) and 30-34 (aOR = 1.23, 95% CI = 1.06-1.43) were more likely to experience IIT at 6 months compared to patients older than 50 years. Similar results were found at 12 months, with the addition of age group 35-39 being associated with higher odds of IIT (aOR = 1.25, 95% CI = 1.12-1.39). Compared to married individuals, patients who reported cohabitating (aOR = 0.25, 95% CI = 0.14-0.35) or being single (aOR = 0.36, 95% CI = 0.18-0.72) were less likely to experience IIT at 6 months. Marital status was not a significant covariate for 12-month IIT in the adjusted multivariable model. Geographic department was not a significant covariate in the 6-month adjusted model, but patients who initiated ART in the Artibonite department were less likely to experience IIT at 12 months compared to those who initiated in the Ouest department (aOR = 0.56, 95% CI = 0.33-0.95). Patients for whom the HIV status of other household members was documented had lower odds of IIT at both 6 months (aOR = 0.76, 95% CI = 0.68-0.85) and 12 months (aOR = 0.83, 95% CI = 0.76-0.91).

Adherence form completion did not demonstrate a significant association with IIT at 6 or 12 months in adjusted models. Reporting one or more missed ART doses in the past four days at a patient's adherence visit was significantly associated with higher odds of IIT at 12 months (aOR = 1.36, 95% CI = 1.25-1.49) but not 6 months. Among reasons for missing a dose, only the category of "has traveled" demonstrated a significant association at 6 months, with patients who reported having traveled showing higher odds of ITT compared to those who did not (aOR = 1.53, 95% CI = 1.12-1.94). In the 12-month adjusted model, there were three categories of

reasons that demonstrated significant associations with IIT. Patients who reported a lack of food (aOR = 1.57, 95% CI = 1.07-2.32) or "other" (aOR = 1.38, 95% CI = 1.06-1.79) as their reasons for missing an ART dose had higher odds of IIT than those who did not report those reasons, whereas patients who reported that they "felt well enough" (aOR = 0.49, 95% CI = 0.35-0.69) were less likely to experience IIT at 12 months than those who did not report that as a reason for missing an ART dose.

Table 3a Association of SDOH and other covariates on IIT at 6 months post-ART initiation: multivariable logistic regression analysis

	IIT at 6 months post-ART initiation			
	Unadjusted odds ratio[a] [95% CI]	**p-value**	**Adjusted odds ratio[b] [95% CI]**	**p-value**
Sex				
Female	1 (ref)		-	-
Male	1.06 [0.96-1.16]	0.24	-	-
Age group (years)				
15-19	0.726 [0.42-1.24]	0.243	0.67 [0.39-1.15]	0.149
20-24	0.862 [0.66-1.12]	0.266	0.83 [0.63-1.08]	0.166
25-29	1.28[1.09-1.51] **	0.0031	1.23 [1.04-1.46] *	0.017
30-34	1.28 [1.11-1.47] ***	0.0083	1.23 [1.06-1.43] **	0.0059
35-39	1.16 [1.01-1.33] *	0.0372	1.12 [0.97-1.29]	0.115
40-44	1.05 [0.91-1.22]	0.515	1.02 [0.88-1.19]	0.754
45-49	0.96 [0.82-1.13]	0.633	0.95 [0.80-1.12]	0.522
50+	1 (ref)		1 (ref)	
Marital status				
Married	1 (ref)		1 (ref)	
Cohabitation	0.29 [0.17-0.52] ***	<0.001	0.25 [0.14-0.35] ***	<0.001
Separated	1.01 [0.79-1.29]	0.933	1.0 [0.79-1.29]	0.97
Single	0.42 [0.21-0.84] *	0.014	0.36 [0.18-0.72] **	0.004
Unknown	1.29 [1.09-1.51] **	0.002	1.23 [1.05-1.45] *	0.012
Widowed	1.03 [0.80-1.33]	0.805	1.06 [1.19-1.94]	0.68
Department				
Artibonite	0.80 [0.41-1.59]	0.535	0.75 [0.37-1.52]	0.42
Grande-anse	1.22 [0.54-2.76]	0.638	1.25 [0.53-2.92]	0.61

Nippes	0.98 [0.31-3.06]	0.971	0.87 [0.27-2.8]	0.82
Nord	1.22 [0.79-1.87]	0.365	1.19 [0.77-1.86]	0.43
Nord-est	1.27 [0.56-2.87]	0.573	1.19 [0.51-2.78]	0.68
Nord-ouest	2.33 [0.93-5.82]	0.070	2.3 [0.90-5.89]	0.08
Ouest	1 (ref)		1 (ref)	
Sud	1.57 [0.91-2.71]	0.103	1.47 [0.84-2.58]	0.18
Sud-est	1.25 [0.49-3.15]	0.634	1.12 [0.43-2.87]	0.83
HIV status of other household members				
Not documented	1 (ref)		1 (ref)	
Documented	0.81 [0.73-0.90] ***	<0.001	0.76 [0.68-0.85] ***	<0.001
Adherence form completion				
Incomplete	1 (ref)	0.632	-	-
Complete	1.04 [0.88-1.23]	0.632	-	-
Number of missed ART doses in the past 4 days				
No missed doses	1 (ref)		1 (ref)	
One or more missed doses	1.25 [1.12-1.39] ***	<0.001	1.09 [0.94-1.27]	0.271
Reason for missing a dose of ART medication in the past 4 days[c]				
Completed all medication	0.90 [0.74-1.51]	0.31	-	-
No reason documented	1.18 [1.02-1.35] *	0.0237	-	-
Felt well enough	0.65 [0.40-1.05]	0.0762	-	-
Has traveled	1.56 [1.23-1.99] ***	<0.001	1.53 [1.12-1.94] ***	<0.001
Did not want medication	1.38 [1.06-1.78] *	0.0159	-	-
Forgot to take medication	0.73 [0.53-1.01]	0.0553	-	-
Other	1.18 [0.84-1.66]	0.345	-	-
Lack of food	0.65 [0.33-1.25]	0.197	-	-
Lost medication	0.56 [0.18-1.78]	0.329	-	-
Uncomfortable taking medication in front of others	0.57 [0.17-1.88]	0.353	-	-

*p-value <0.05
**p-value <0.01
***p-value <0.001
[a] Unadjusted model: bivariate logistic regression with independent variable as fixed effect and clinic site as random effect
[b] Adjusted model: multivariate logistic regression with significant independent variables from bivariate model as fixed effects and clinic site as random effect
[c] Reference category for each binary variable is that the specific reason was not chosen

Table 3b Association of SDOH and other covariates on IIT at 12 months post-ART initiation: multivariable logistic regression analysis

	IIT at 12 months post-ART initiation			
	Unadjusted odds ratio[a] [95% CI]	**p-value**	**Adjusted odds ratio[b] [95% CI]**	**p-value**
Sex				
Female	1 (ref)		-	-
Male	1.04 [0.97-1.12]	0.274	-	-
Age group (years)				
15-19	1.07 [0.73-1.56]	0.734	1.02 [0.69-1.49]	0.93
20-24	1.17 [0.96-1.42]	0.123	1.15 [0.95-1.40]	0.15
25-29	1.31 [1.15-1.50] ***	<0.001	1.29 [1.13-1.47] ***	<0.001
30-34	1.31 [1.17-1.48] ***	<0.001	1.31 [1.16-1.47] ***	<0.001
35-39	1.26 [1.12-1.40] ***	<0.001	1.25 [1.12-1.39] ***	<0.001
40-44	1.11 [0.99-1.25]	0.080	1.11 [0.98-1.25]	0.081
45-49	0.97 [0.86-1.11]	0.696	0.97 [0.86-1.11]	0.71
50+	1 (ref)			
Marital status				
Cohabitation	0.90 [0.68-1.19]	0.480	-	-
Married	0.88 [0.77-0.99] *	0.034	-	-
Widowed	0.90 [-.77-1.06]	0.214	-	-
Separated	0.86 [0.74-1.00]	0.062	-	-
Single	1.28 [0.88-1.84]	0.195	-	-
Unknown	1 (ref)		-	-
Department				
Artibonite	0.57 [0.33-1.0]	0.054	0.56 [0.33-0.95] *	0.03
Grande-anse	1.07 [0.54-2.1]	0.84	1.24 [0.66-2.34]	0.51
Nippes	1.05 [0.42-2.64]	0.92	1.0 [0.42-2.42]	0.98
Nord	0.97 [0.68-1.39]	0.87	0.99 [0.72-1.39]	0.99

Nord-est	0.87 [0.44-1.72]	0.69	0.91 [0.48-1.72]	0.77
Nord-ouest	1.54 [0.70-3.37]	0.28	1.53 [0.73-3.22]	0.26
Ouest	1 (ref)		1 (ref)	
Sud	1.15 [0.73-1.82]	0.53	1.23 [0.80-1.89]	0.34
Sud-est	1.60 [0.77-3.36]	0.21	1.58 [1.07-2.32]	0.20
HIV status of other household members				
Not documented	1 (ref)		1 (ref)	
Documented	0.84 [0.77-0.92] ***	<0.001	0.83 [0.76-0.91] ***	<0.001
Adherence form completion				
Incomplete	1 (ref)		-	-
Complete	1.02 [0.89-1.17]	0.773	-	-
Number of missed ART doses in the past 4 days				
No missed doses	1 (ref)		1 (ref)	
One or more missed doses	1.38 [1.27-1.50] ***	<0.001	1.36 [1.25-1.49] ***	<0.001
Reason for missing a dose of ART medication in the past 4 days[c]				
Completed all medication	0.86 [0.74-1.0]	0.055	-	-
No reason documented	1.35 [1.21-1.51] ***	<0.001	-	-
Felt well enough	0.61 [0.44-0.85] **	0.003	0.49 [0.35-0.69] ***	<0.001
Has traveled	1.29 [1.05-1.59] *	0.016	-	-
Did not want medication	1.32 [1.07-1.62] **	0.009	-	-
Forgot to take medication	1.11 [0.88-1.39]	0.384	-	-
Other	1.71 [1.32-2.21] ***	<0.001	1.38 [1.06-1.79] *	0.017
Lack of food	1.81 [1.23-2.65] **	0.0024	1.57 [1.07-2.32] *	0.022
Lost medication	0.82 [0.38-1.75]	0.612	-	-
Uncomfortable taking medication in front of others	1.75 [0.89-3.43]	0.107	-	-

*p-value <0.05

**p-value <0.01

***p-value <0.001

[a] Unadjusted model: bivariate logistic regression with independent variable as fixed effect and clinic site as random effect
[b] Adjusted model: multivariate logistic regression with significant independent variables from bivariate model as fixed effects and clinic site as random effect
[c] Reference category for each binary variable is that the specific reason was not chosen

Discussion

This study explored the types and completeness of SDOH data in Haiti's EMR and investigated associations with IIT outcomes at 6- and 12-months post-ART initiation. While we found that iSantéPlus contained some variables related to social and community context and health and clinical care, our desk review revealed fewer variables related to physical and built environment, food, education, and economic stability. While adherence form completion was high at around 90%, only one-third of patients had completed household composition data. One in ten patients experienced IIT at 6 months and nearly one in five experienced IIT at 12 months post-ART start date. Documentation of the HIV status of other household members was associated with a lower likelihood of IIT at both time points. There were several SDOH reasons associated with IIT at 6 or 12 months, including travel and lack of food.

In our review of all variables across adult HIV care forms, 39.6% of variables fell within the social and community context domain, 17% within the health and clinical care domain, and 13% in the physical and built environment domain. There was a dearth of variables within the domains of food and education, and we found no current variables within the domain of economic stability. These results contrast with a systematic review of US-based social health screening tools conducted by Henrikson et al. which used the same six domains of SDOH. The review found that out of 21 tools, questions pertaining to physical and built environment were included in 100% of tools and questions within the domain of economic stability were assessed

in 90.5% of tools. While social and community context-related questions made up the largest category in Haiti's EMR, followed by health and clinical care, these domains ranked third and last among US-based tools.[37]

Although the contexts of these findings differ significantly in terms of both setting and focal health areas, it is nonetheless interesting to see how the collection of SDOH data within health care settings and EMRs is distributed across domains, and consider how this might impact resulting interventions for patient-centered care. It makes sense that social and community context variables are a large portion of Haiti's existing EMR, given the pertinence of this domain to HIV in terms of constructs such as stigma, discrimination, and social support systems. However, given findings around risk factors for poor adherence such as the inability to meet basic needs and transportation challenges among PLWH in Haiti [13,16] and levels of education and employment among PLWH globally[41–45], considering an expansion of variables to include additional items within the SDOH domains of physical and built environment, education, food, and economic stability may prove quite useful in analyzing additional risk factors for IIT. A systematic review of the integration of SDOH within EMRs and the impact of SDOH on risk prediction of various clinical outcomes published in 2020 found that only two out of 71 identified studies were conducted in an LMIC (both from China). Studies that used individual-level SDOH data reported higher levels of predictive ability compared to studies that used externally-sourced community-level SDOH data.[34] A more recent study assessing the accuracy of EMR variables in combination with sociodemographic survey data to predict the risk of interruption in care among PLWH in Tanzania found that survey variables "modestly improved model performance".[46] So, while there is still a gap in the literature on SDOH and EMR

integration in LMICs, research efforts are growing and there is strong evidence from other settings demonstrating the value of collecting patient-level SDOH data.

Data completeness is an essential component of many existing data quality assessment frameworks.[32,47,48] Our assessment found that 90.2% of patients had a fully completed adherence form at their adherence counseling visit within the first 6 months of starting ART, meaning about 10% of patients had missing adherence data. This level of data missingness is comparable with findings from an assessment of data quality in EMRs for ART programs in 15 countries across Africa, South America and Asia conducted from 2006-2007 which found that the median percentage of data missingness for key clinical variables was about 10.9% per ART site.[23] In contrast, 67.4% of patients in our study had missing (incomplete) household composition data.

There is demonstrated interest in the wider literature to use routine clinical, laboratory, behavioral, and demographic data to run machine learning models for predicting HIV treatment and viral suppression outcomes, while there is limited research on the use of SDOH data for these purposes.[49–52] Ensuring data completeness for SDOH-related variables such as the HIV status of other household members may be less prioritized as a consequence.

Data collection of the household composition variable may have been hindered by patient-level barriers of non-disclosure to family members and a resulting discomfort or unwillingness to answer questions about the HIV status of household members. Qualitative research on cultural and contextual factors affecting ART adherence in Haiti found that non-disclosure of one's status to family members or significant others was a key barrier.[53] Another possible explanation could

be at the health systems level- resource challenges in terms of time and human resource capacity may contribute to health care workers not collecting or documenting SDOH data. Research has shown that even in high-income countries (HICs) such as the US, the uptake of SDOH data collection within electronic health record systems has been hindered by barriers related to organizational capacity, lack of standardized screening tools, and lack of local resources to address patients' social needs.[54,55] The use of natural language processing to extract SDOH data from unstructured, free-text clinical notes and recommendations to financially incentivize the collection of SDOH data in US Medicaid programs are some examples of efforts to address these barriers.[34,56]

We assessed the proportion of patients who reported various categories of reasons for missing an ART dose at their adherence counseling visit. Among our patient sample, "felt well enough" was the third most reported reason for patients missing an ART dose. This is consistent with a qualitative study amongst PLWH in Haiti's urban centers that found most patients understand the importance of taking medication consistently but some hold a belief that ART does not need to be taken if the patient is feeling well and not exhibiting signs of illness.[53] While feeling well was cited as a reason for missing doses, it was a protective factor for IIT at 12 months and associated with a 51% lower likelihood of IIT. Given some of the beliefs around ART ineffectiveness when a patient does not feel ill, this finding is contradictory to what we would have expected as a higher likelihood of IIT. This could reflect that adherence and retention in care are related but distinct concepts- one can miss medication doses but still be retained in care. This apparent contradiction could suggest the need for future research on health literacy about emphasizing the need to take medication even when feeling well.

It was surprising that the category “lack of food” represented only 1.9% of reported reasons for missing a dose, given a belief expressed among PLWH in the aforementioned study that eating nutrient-rich foods, which are inaccessible or unaffordable for many, is critical for ensuring the effectiveness of medicine and mitigating side effects.[53] The high percentage of patients who missed an ART dose (40.2%) because they “completed all medication” leaves many gaps in our understanding of barriers to picking up medication on time and daily ART adherence and limits our ability to interpret findings with this data. Existing qualitative research provides some insight into understanding why a patient might not have returned for a refill in a timely manner after completing their medication, such as a fear of being seen at the clinic or because they obtained medications from another source.[53] However, the method in which the categories are currently defined does not allow the capture of quantitative data in the EMR to compare with these qualitative findings. It is important to recognize that there are challenges of collecting this type of data due to the sensitive nature of stigma and disclosure topics. However, there is nonetheless a need for improved questions on such aspects of adherence. An existing body of research around efforts to quantitatively measure aspects of stigma among PLWH can serve as reference.[57–65]

Our study found several variables significantly associated with IIT at 6- and 12-months post-ART initiation. Being between the ages of 25-29 as compared to being over 50 years was associated with a 23% and 29% higher likelihood of experiencing IIT at 6 and 12 months, respectively. Our results are consistent with previous findings in Haiti of the association between younger age and lower adherence.[13] A reported lack of food was an important correlate of IIT at

12 months, with patients who reported this as a reason for missing an ART dose being 57% more likely to experience IIT. If we consider food access as interconnected with someone's ability to meet their basic needs, this finding is consistent with prior research as well.[13] A patient reporting having traveled as their reason for missing an ART dose was associated with 53% higher odds of IIT at 6 months. To our knowledge there is not existing literature which explores potential sub-categories and reasons for travel among PLWH in Haiti. Although beyond the scope of this study, it would be interesting to investigate the association between travel and IIT within each of Haiti's geographic regions. Relatedly, our finding that patients who initiated ART in the Artibonite geographic department had a 44% lower likelihood of IIT at 12 months as compared to those who initiated in the Ouest department is worth exploring further.

Although completion of the adherence form was not found to be significant on IIT outcomes at either time point, this could be limited by the fact that we only assessed completion rates for the patient's first adherence visit, and the fact that we limited our sample to only patients with at least one adherence visit. This finding should not be interpreted as discounting the importance of collecting adherence data in its entirety at relevant patient encounters. In terms of our findings around the significance of documentation of the HIV status of other household members on IIT outcomes, it is possible that having such information documented is a proxy indicator for patients' disclosure to household members and other close relations. This could possibly enable stronger support systems and be an important factor in the associated lower odds of IIT at both 6 and 12 months.

Limitations

There were several limitations to our study. We were not able to track patients if they transferred to a different facility and our outcome of interest was limited to documented instances of IIT at the facility where the patient experienced ART services. Measuring IIT as a binary outcome rather than the total number of IIT instances also limited our analysis in terms of understanding the frequency or severity of IIT risk, as well as the risk of repeated instances of IIT. There were also significant challenges around data structure and extraction that impacted the number of variables we could include in our analysis. We observed a large amount of missing data among the household composition variables which impacted our analysis. Missing data is a common challenge in observational studies, and potential solutions include imputation to fill in values.[12,23] However, this can introduce bias, for example if the data are not missing at random, defined as when the missingness of a variable is associated with the value of the variable.[66] This is especially a concern when collecting data on social determinants of health which may not be as easily structured into quantitative formats or suitable for imputation.[12,23,32] Therefore, we decided not to impute the missing household data in order to minimize the introduction of bias when assessing the relationship between SDOH variables and IIT.

Strengths and future research

Strengths of this study included a sample size with patient data from about 60% of clinic sites and robust pharmacy data on ART refills for our outcome variable. There is a high level of enthusiasm from collaborators and implementers to leverage routine iSantéPlus data for improving patient outcomes and to use results of this analysis to inform efforts around developing a social risk screening tool which will collect data on SDOH.

In conclusion, as the use of routine data from iSantéPlus to improve patient outcomes for PLWH expands in Haiti and other LMICs with similar EMR systems, there is an opportunity to collect and benefit from individual-level SDOH data. This exploratory analysis highlighted current gaps and areas for future work including: ensuring data for existing key variables of household composition and adherence are collected and documented in Haiti's EMR, better defining the categories of reasons for missing an ART dose, developing new questions for assessing adherence barriers, and considering an expansion of variables to include items within the currently lacking SDOH domains that may prove to be important predictors of patients at risk of interruption in HIV treatment. As the provision of "social advantages" such as transport subsidies, vocational training, and food supplement packages for PLWH in Haiti has been scaled back with the adoption of Test and Start and larger numbers of patients are engaged in care and treatment[53], it is critically important to understand the social health needs of PLWH and identify possible interventions to provide enhanced support for those at highest risk of treatment interruption. Given the increasing presence of EMRs for HIV care and treatment programs in many low-resource settings, the utility of these systems to improve patient engagement and quality of care must be emphasized.[46] There remains potential to better leverage the existing robust iSantéPlus infrastructure to predict patients at highest risk of poor HIV outcomes and develop interventions for intensified support using data collected across a spectrum of social determinants.

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Appendix

Table 1c Categorization of additional variables by SDOH domain

Source form	Variable Description	Response Options	SDOH construct(s) encompassed	Primary SDOH domain encompassed
Household counseling form	Does the patient have a companion?	Yes No Unknown	Social support systems	Social and community context
	Did the patient come to the medical examination?	Yes No Unknown	Social support systems	Social and community context
	Patient communicated HIV status to:	Spouse Father/mother/parent Child Friend Other Nobody	Social support systems	Social and community context
	Level of psychosocial support of the relative:	Weak Medium Good Excellent	Social support systems	Social and community context

	Assimilation of information by patient's companion	Unsatisfactory Acceptable Excellent	Health literacy	Education
	Support level estimate	Limited Medium Good	Social support systems	Social and community context
	Acceptance by the patient of the home care of the employees of the ARV program	Anytime Occasionally Never	Quality of care	Health and clinical care
	Barriers to accepting home visits	Stigma of relatives Stigma of neighbors Other	Stigma	Social and community context
	Probable reasons preventing the patient from respecting the frequency of follow-up visits	Cost of transport/transport not available	Transportation	Physical and built environment
		Patient's condition	NA	NA
		Inadequate support	Social support systems	Social and community context
		Fear of being seen at a treatment clinic	Stigma	Social and community context
		Other	NA	NA
	The patient underwent emotional abuse (asks about abuse from partner or family member):	In the past In progress	Discrimination Violence	Social and community context
	The patient underwent verbal abuse (asks about abuse from partner or family member):	In the past In progress	Discrimination Violence	Social and community context
	The patient underwent physical abuse (asks about abuse from partner or family member):	In the past In progress	Discrimination Violence	Social and community context
	Patient has limited understanding of ARV treatment	Yes No Undetermined	Health literacy	Education

	and need for adherence			
	Patient refuses to accept HIV status	Yes No Undetermined	Stigma	Social and community context
	Risk of family violence	Yes No Undetermined	Discrimination Violence	Social and community context
	Transport barriers	Yes No Undetermined	Transportation	Physical and built environment
	Housing issues	Yes No Undetermined	Quality of housing Living conditions	Physical and built environment
	Insufficient supply (lack of food, lack of gas)	Yes No Undetermined	Food insecurity	Food
	Hygiene issues/sanitary facilities	Yes No Undetermined	Living conditions	Physical and built environment
Home visit form	Reason for missed clinic visit	Cost of transport/transport not available	Transportation	Physical and built environment
		Cost of services/drugs	Access to health care	Health and clinical care
		Inadequate care staff/services	Quality of care	Health and clinical care
		Medication side effects	NA	NA
		Too ill	NA	NA
		Seeking alternative care/traditional medicine	Access to health care	Health and clinical care
		Fear of being seen at an intake site caring for HIV patients	Stigma Discrimination	Social and community context
	Services rendered:	Counseling/psychosocial support for patient or family	Social support systems	Social and community context
		Food aid	Food security	Food
		Kit for home care	Access to health care	Health and clinical care
		Drug deliveries	Access to health care	Health and clinical care
		Health tips	Health literacy	Education
		Other	NA	NA