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Geographic ecological momentary assessment methods to examine spatio-temporal exposures associated with marijuana use among young adults: A pilot study

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Abstract

Background.—This study demonstrates the use of geographic ecological momentary assessment (GEMA) methods among young adult marijuana users.

Method.—Participants were 14 current marijuana users ages 21–27 living in Greater Seattle, Washington. They completed brief surveys four times per day for 14 consecutive days, including measures of marijuana use and desire to use. They also carried a GPS data logger that tracked their spatial movements over time.

Results.—Participants completed 80.1% of possible EMA surveys. Using the GPS data, we calculated daily number of exposures to (i.e., within 100-m of) marijuana retail outlets (mean = 3.9 times per day; SD = 4.4) and time spent per day in high poverty census tracts (mean = 7.3 hours per day in high poverty census tracts; SD = 5.1).

Conclusions.—GEMA may be a promising approach for studying the role spatio-temporal factors play in marijuana use and related factors.

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Keywords

geographic ecological momentary assessment; spatio-temporal factors; marijuana; young adults; geographic information system; poverty

1. Introduction

Given evidence for increasing prevalence of marijuana use, particularly for young adults (YAs),[1–3] it is important to understand factors that can lead to problematic marijuana use across multiple levels of influence, including ecological-level contexts. Studies have described associations between neighborhood-level socioeconomic disadvantage and more frequent marijuana use.[4,5] Further, as states legalize the use and sales of marijuana for non-medical (or recreational) use among adults, there is concern about how exposure to marijuana retail outlets may shape use.[6] Recent evidence suggests that geographic availability of recreational marijuana retail outlets may be associated with greater likelihood of marijuana use and frequent use.[7,8]

Most studies of ecological context have treated the spatial exposure as static (e.g., level of disadvantage or outlet density for one's neighborhood of residence). However, individuals may traverse multiple areas over time as part of routine activities (e.g., school, work, recreation).[9,10] Thus, one's residential environment represents only a subset of total exposure. For example, using global positioning system (GPS) methods to track movements of San Francisco Bay Area adolescents, Byrnes and colleagues showed that adolescents spent substantial time outside their neighborhood of residence, and that greater overall exposure to area-level disadvantage and alcohol outlets were more common among alcohol and marijuana users.[11]

An extension of this research could consider how recent spatial exposures could influence one's event-level marijuana use. This type of research could be conducted using a geographically-explicit ecological momentary assessment (GEMA), which integrates GPS methods and ecological momentary assessment (EMA) that can capture self-reported behaviors and experiences in real- or near real-time in a naturalistic setting.[12,13] GEMA has been increasingly used in other substance use and mental health research.[14–19]

Using a sample of 14 YA marijuana users living in the greater Seattle area, where recreational use of marijuana is legal, this paper demonstrates the use of GEMA methods, including examples of spatio-temporal measures that can be created, towards the investigation of the role of spatio-temporal factors in marijuana use.

2. Materials and Methods

2.1. Study sample

Study participants were identified from a list of 130 YAs who participated in two separate research projects related to substance use. Inclusion criteria for the current study included being 21 to 27 years of age; currently residing in King County, WA; and reporting marijuana use within the past 30 days. Fifty-two individuals completed the screening survey. Of those, 26 met study criteria and agreed to meet for an informed consent and training session. Fifteen individuals provided informed consent and proceeded with study procedures. Data collection was conducted from July to September 2018. The University of Wash-ington Institutional Review Board approved this study.

2.2. Study procedures

2.2.1. In-person consent and survey.—Participants completed the informed consent process at study offices and completed a web-based survey about marijuana and other substance use, demographic characteristics, and psychosocial factors.

2.2.2. EMA procedures.—Participants were asked to complete four EMA assessments per day for 14 consecutive days. Surveys were administered online and could be completed from any web browser, including a cell phone's web browser. Participants were prompted via text message and email that the survey window was open. A longer survey was administered each morning, to be completed between 8 and 10 am. Shorter surveys were administered at random times during three time windows: late morning/early afternoon (11 am – 2 pm), afternoon (2 pm – 6 pm), and evening (6 pm – 10 pm). For these three shorter surveys, participants had one hour to complete the survey. Participants were compensated for their time with an amazon.com gift card: $4 for each morning survey completed, $1 for each of the later random surveys completed, and a $17 bonus for completing 80% of all possible surveys.

2.2.3. GPS procedures.—At the in-person informed consent session, participants were provided a GPS data logger (Qstarz BT-Q1000XT, Qstarz International Co., Ltd., Taipei, Taiwan) and charger. The loggers were configured to collect spatial coordinates and time stamps every 45 seconds. Participants were instructed to carry the logger during waking hours and to charge it every evening. After the EMA measurement burst, participants returned the logger in-person at the study site as part of an in-person exit interview.

2.3. EMA measures

2.3.1. Marijuana use.—At the morning survey, participants were asked whether they used marijuana since they awoke and, if so, the count of occasions of use and the time at which using started and stopped. They were also asked to report on their marijuana on the previous day, including the total number of occasions. At the three other daily surveys, they reported whether or not they used since the last completed survey and if so, time of last use.

2.3.2 Desire to use marijuana.—At each EMA survey, participants were asked about their current desire to use marijuana on a scale of 0 (no desire) to 8 (strong desire).

2.4. Spatio-temporal measures

2.4.1. Marijuana outlet exposure.—The Washington State Liquor Cannabis Board provided geospatial coordinates for businesses with licenses to sell recreational marijuana at the time of data collection. Euclidean (straight-line) buffers of 100 m around each outlet were created. GPS point data were chained to linestrings using spatial coordinates and ordered by time stamp. Separate lines were made for each subject/calendar-day combination to represent each participant's daily path. The daily path linestrings were then "clipped" by marijuana retail outlet buffers, allowing us to calculate the number of times a participant passed within a 100 m buffer of an outlet each day to quantify exposure. Because of interest in outlets as a visual cue, we selected this buffer size as a distance which the storefront and signage should be visible to individuals.

2.4.2. Area-level poverty.—Data from the American Community Survey were used to create measures of exposure to census-tract-level poverty using the 2012–2016 averaged estimates. Tracts were stratified into tertiles using the percentage of households living below 100% of the federal poverty threshold. We intersected the GPS tracks described above with census tract boundaries to calculate the number of hours each day spent within high poverty neighborhoods.

2.5. Analyses

Descriptive statistics included the EMA survey response rate, means and standard deviations for non-categorical EMA measures, and percentages for EMA categorical measures (e.g., any marijuana use). To highlight linkages between GPS and EMA data, we estimated Spearman correlation coefficients for between-person correlations of overall exposure to geospatial factors with cumulative marijuana use and desire to use across the EMA measurement period.

Management and analysis of spatial data (GPS, outlets, census) was performed with PostgreSQL/PostGIS, and R statistical software [20] was used for statistical analyses.

3. Results

One participant, whose GPS data were not captured by the data logger due to malfunction, was excluded from analyses, leaving 14 participants. Sample characteristics obtained from a separate baseline survey are available in an online supplemental table. Participants demonstrated high rates of response to the EMA surveys. The average response rate across participants was 80.1% (SD = 23.4%). Despite the first morning survey asking many more items, response rates were nearly identical across time of day (minimum 79.6% for the first morning survey; maximum of 81.7% for afternoon survey).

Based on the EMA self-reported data, we assessed frequency of marijuana use across days. In this sample, the average person-level percentage of assessments during the study for which marijuana use was reported since the prior assessment (or since waking up in the morning in the case of the first morning assessment) was 13.9% (SD = 11.7). Marijuana use was more commonly reported at the later-in-the-day surveys (1^{st} survey: 6.4%; 2^{nd}: 9.7%; 3^{rd}: 13.8%; 4^{th}: 23.4%). In regards to desire to use marijuana, across all observations, the mean was 1.5 (SD = 2.0). Relative to between-person, there was substantial within-person variability in desire to use (ICC = 0.45).

Using GPS data, we assessed exposure to marijuana retail outlets during the study. Figure 1 shows one participant's travel path over the course of a day when 8 outlets were passed in close proximity. In the sample, participants were within 100 m of an outlet 3.9 times per day (SD = 4.4). There was also within-person variability in frequency of retail outlet exposure (mean within-person SD = 5.2). We were also able to estimate exposure to neighborhood-level poverty. On average, participants spent 7.3 hours per day within census tracts in the highest tertile of poverty (SD = 5.1 hours). The average within-person SD of time spent in the highest poverty tracts over the 14 days was 4.3 hours, reflecting substantial within-person variability.

Finally, to demonstrate EMA and GPS data linkages, after calculating aggregated levels of the variables for each participant over the measurement burst, we observed that total number of marijuana use occasions showed a sizeable correlation with both cumulative exposure to marijuana retail outlets (Spearman's rho = 0.62) and neighborhood poverty (rho = 0.45) as shown in Table 1. Correlations of the spatial exposures with desire to use were smaller (outlet rho = 0.37; poverty rho = 0.19).

4. Discussion

Collection of passive data via GPS methods can provide researchers with valuable objective assessment of movements through space and time while minimizing participant response burden.[12] This pilot study demonstrated types of spatio-temporal exposures that could be measured utilizing GPS data that tracked participants' movements across geographic space and time in combination with other geographically referenced data. With the high compliance for the EMA survey protocols with reasonable participant compensation for completion of study procedures, the GEMA design may be a feasible and practical approach to better understand the role of spatio-temporal exposures across one's activity spaces in marijuana-related behaviors.

In this study, participant locations were tracked utilizing a dedicated GPS logger. Use of participants' own GPS-enabled smartphones may be an alternative approach that may further aid feasibility and practicality. Nearly 95% of YAs own a smartphone, [21] and apps have been developed enabling smartphones to collect GPS as well as EMA data. In addition to being more likely that YAs would carry their smartphone at all waking hours compared to the study GPS logger, this would make the GEMA strategy more cost-effective since additional purchase of GPS loggers would not be necessary. One trade-off of capturing spatial movements with a phone, however, is that enabling GPS tracking may quickly reduce battery life, particularly at high temporal resolution. [22] Study designs and analyses with phone-based spatial tracking would need to take into account less frequent recording of spatial location or use other approaches that only trigger location capture when movement is detected by the smartphone's accelerometer.

With GEMA methodology, investigators can examine research questions not conducive to traditional survey approaches such as whether certain types of objectively-measured environmental exposures are associated in near real-time with an occasion of marijuana use or related factors. For example, to investigate whether retail outlets may serve as cue-induced triggers for use or desire to use, GEMA studies that link EMA measures collected multiple times per day and time-stamped GPS data could explore whether being in close proximity to retail outlets may increase likelihood of use or desire to use within a certain time interval (e.g., 2 hours). This approach may also be relevant for understanding spatial factors related to occasions of particularly high risk forms of marijuana use such as simultaneous use of marijuana and another substance including alcohol or tobacco, such that the effects of the two overlap. Occasions of simultaneous alcohol and marijuana use, in particular, carry excess risk of health and psychosocial consequences beyond either alcohol or marijuana use alone.[23–25] Thus, it may be especially important to identify spatial antecedents of simultaneous that might be uncovered via GEMA designs. Finally, assessments multiple times per day, GEMA may be particularly relevant for studies that include heavy marijuana users that use daily or near-daily. GEMA methods that assess marijuana use and associated cognitions throughout the day may allow for finer-grained understanding of how spatial factors inform variability in use among these heavy users.

Although this approach presents an innovative data collection approach that can help answer novel questions about spatial exposures that occur across one’s activity space and temporally proximal associations between spatial factors and marijuana behaviors, like with other study designs, establishment of temporal precedence and causation will require careful consideration. For example, intent and desire to use marijuana may precede exposure to a retail outlet for purchase, and would bias inferences about the role of retail outlet exposure acting as a cue-induced trigger for marijuana use and desire to use. In this scenario, investigators may not want to count certain exposures to outlets lasting longer than a certain duration in analyses because they may likely be visits with the intent to purchase. The GPS methods can also be used to capture cumulative exposure to spatial factors over time, which can be used to explore relations with longer-term outcomes. However, there may be numerous factors that predispose more frequent marijuana users to spend in time in certain types of locations. Assuming relevant confounders are measured, it may be possible to employ analytic strategies, such as inverse probability weighting, that balance distribution of confounders and reduce the potential for confounding and self-selection biases when exploring these questions.[26,27]

It is important to consider limitations of this pilot study. Of note, this study included a convenience sample of only 14 participants. Thus, we are limited in our inferences about the distribution of study variables and their correlations. Further, the study was conducted in a single metropolitan area in the Pacific Northwest. This may be particularly relevant because the distribution of the spatial exposures can vary across different cities and regions. As research in retail outlet availability and exposure move forward, it will be informative to include multiple diverse study areas to improve generalizability.

4.1. Conclusion

GEMA may be a promising approach for studying the role of geospatial factors in real-time and longer-term patterns of marijuana use and related behaviors among YAs. Greater understanding of how exposure to environmental contexts shapes marijuana behaviors may lead to public health strategies, such as regulations and zoning policies about the number and location of outlets able to be established within specific geographic areas. Importantly, research with GEMA may also aid in development of individually-tailored just-in-time interventions that could provide targeted mHealth intervention messages to individuals at high-risk places and moments.[28]

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- This study applied geographic ecological momentary assessment (GEMA) methods in young adult marijuana users.
- Spatio-temporal variables such as exposure to marijuana retail outlets were created.
- Spatio-temporal variables can be temporally linked with EMA data.
- GEMA may help identify spatio-temporal factors associated with real-time marijuana use.

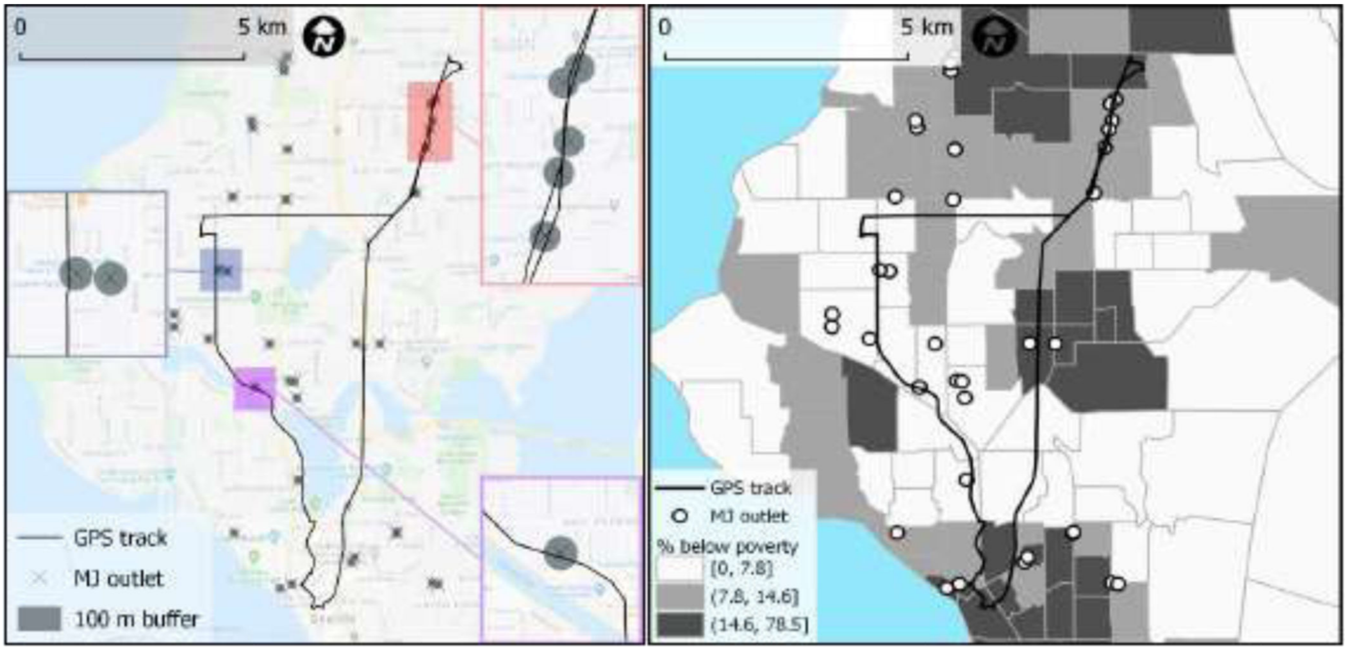

Figure 1:
One subject's travel path over a single day with marijuana retail outlet buffers and insets showing detail (left) and tertiles of percent below federal poverty level (right).

Table 1.

Spearman correlations among marijuana use occasions, mean desire to use, average number of exposures to retail outlets per day, and average hours spent in high poverty neighborhoods per day.

	1.	**2.**	**3.**	**4.**
1. Total marijuana use occasions	1			
2. Desire to use marijuana	.63	1		
3. Exposure to marijuana retail outlets	.62	.37	1	
4. Exposure to high poverty neighborhoods	.45	.19	.49	1