Mobile daily diaries to characterize stressors and acute health symptoms in an environmental justice neighborhood

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ABSTRACT

Low-income communities and communities of color face multiple, cumulative environmental and social burdens. Methods development in environmental justice research has largely focused on spatial and quantitative approaches. Less attention has been paid to developing methodologies that help collect information on everyday stressors and quality of life experiences for residents in overburdened communities. Mixed methods approaches can be one way to structure study designs that help consider how residents experience environmental and socioeconomic impacts in a localized community context. In neighborhoods burdened by cumulative stressors, traditional cross-sectional epidemiological research designs can also be challenging, as well as limited or narrow in their application. However, repeat sampling of measures within a vulnerable population can approach a quasi-experimental design and help consider variations within residents in a single neighborhood as well as better parse relationships between exposures and outcomes. Through a community-academic partnership with university partners, local community partners, and a local promotores de salud (community health workers) network, we pilot tested a novel mobile daily diary approach in both English and Spanish in an urban, predominantly immigrant community in South Los Angeles as a potential method to collect information on daily stress, environmental quality, and health status/symptoms. We collected resident responses via a once per day 7-day SMS/text messaging survey. We sought to gather granular data on daily resident experiences of air pollution and environmental hazards. Residents reported acute health symptoms and stressors, with repeat measures demonstrating how residents might rank, categorize, or cope with stressors. We find that residents in environmental justice communities record variation in their daily diary responses and document changes in environmental quality, stressors, and odors. Refining this type of method could enable a more rigorous examination of co-occurrences of environmental quality and acute health symptoms. This approach supports the inclusion of residents in the research process and helps more systematically integrate open-ended environmental health relevant data in environmental justice efforts. Used with measured data such as air monitoring or health measures, mixed methods generated data can help support efforts that aim to alleviate sources of daily stress, alongside efforts to reduce overall pollution burdens. Mobile daily diaries can be one way to capture variable responses to environmental quality, acute health symptoms, and stressors.

1. Introduction and background

Low-income communities and communities of color face multiple, cumulative, and synergistic environmental and social burdens (Morello-Frosch et al., 2011; Solomon et al., 2016). Efforts to characterize cumulative burdens in environmental justice research have led to tools such as CalEnviroScreen that jointly consider factors such as poverty and linguistic isolation alongside presence of environmental

hazards(Cushing et al., 2015). These approaches can help delineate locations of overburdened neighborhoods and support efforts to identify, invest in, alleviate, and remediate harm(Lee, 2020; Vanderwarker, 2015). Less attention has been paid to developing methodologies that help collect information on everyday stressors and quality of life experiences for residents in cumulatively impacted communities. Mixed methods approaches can be one way to structure study designs to consider how cumulative environmental and socioeconomic burdens may play out in a localized community context. Qualitative information can add analytical depth to spatial and quantitative research, help reveal how residents living under conditions of environmental injustice experience everyday non-chemical stressors and pollution, can capture health information, and be structured to complement quantitative measures(Brown, 2003; Hoover et al., 2015). For example, in studies of transportation and low-income groups, travel time models established baseline time costs, but interviews revealed additional stressors that intensified time burdens, such as worries related to uncertain transportation and asking for rides that could strain social relations(Lowe and Mosby, 2016). In environmental health research, qualitative and mixed methods data have the potential to improve understandings of complex exposure pathways, including the influence of contextual social factors on environmental health and health outcomes(Madeleine Kangsen, 2010).

In neighborhoods burdened by cumulative stressors, traditional cross-sectional epidemiological research designs can be challenging, as well as limited or narrow in their application(Wing, 1998). However, repeat sampling of measures within a vulnerable population can approach a quasi-experimental design and help consider variations within residents in a single neighborhood as well as better parse relationships between exposures and outcomes. Self-reported health has been shown to be a reliable measure of health, with substantial agreement with physician diagnoses(Leidy et al., 2014; Weakley et al., 2013). The daily diary format is one potential method that can support participant data collection once per day over a defined time period and allows for frequent measurement of within-person daily variables as well as between-person variables, thereby permitting participants to act as their own controls, and reducing recall bias(Gunthert and Wenze, 2012). While allowing for in-depth contextual data collection, methods such as interviews or focus groups are not an agile way to gather day-to-day contextual information on how residents experience pollution– and how such experiences may vary in short time scales. By using within-person analysis, participants' reaction to situations can be compared relative to their own baseline, and data including non-chemical stressors and pollution experiences, can be paired with measures such as air pollution monitoring. The daily diary design has been refined in stress and psychology literatures, pediatric health (Voorend-van Bergen et al., 2014), and environmental justice contexts (Delfino Ralph et al., 2003; Gunthert and Wenze, 2012; Heaney et al., 2011; Torres and Ong, 2010; Wing et al., 2008a). For example, use of daily diaries has been demonstrated to provide more sensitive activities that can support asthma control(Okupa et al., 2013). Other options for measuring within person experiences are to use multiple assessments at different times during the day, such as experience sampling studies or ecological momentary assessment (EMAs). However, compliance rates can be a greater challenge when participants are asked to respond multiple times per day(Gunthert and Wenze, 2012).

Prior research in environmental justice communities have examined resident self-reported stress and perceptions of neighborhood quality through methods such as focus groups and household surveys. Residents reported neighborhood stressors to include police and safety, physical disorder and neglect, and racism, while better aesthetics, higher perceived safety, and greater social cohesion were associated with lower self-reported stress (Henderson et al., 2016; Shmool et al., 2015). Studies utilizing in depth interviews and photo voice with youth living in environmentally burdened neighborhoods identified community level concerns to include micro-level hazards nearby housing, general

neighborhood disorder, abandoned housing, and crime as everyday challenges (Teixeira and Zuberi, 2016). In addition, studies have found that negative odors can hamper quality of life in both rural and urban environmental justice communities(Kitson et al., 2019; Wing et al., 2008b).

Through this community-academic partnership with university partners, local community partners, and a local *promotores de salud* (community health workers) network, we pilot tested a novel mobile daily diary approach as part of a longer-term epidemiology study. We aimed to test the feasibility for gathering participant data through SMS/text delivered to participants through in an environmental justice neighborhood in Los Angeles in both English and Spanish (based on participant preference), in an urban, predominantly immigrant community in South Los Angeles. We sought to understand 1) whether participants respond to a daily questionnaire delivered via mobile phone differently day-to-day and 2) to gather textual, qualitative data as to what factors residents identified that affected their health and environment over the course of the week. We evaluated this method for feasibility of collecting information on daily stress, environmental quality, and health status/symptoms. Los Angeles is home to well-documented neighborhood "riskscapes", where air pollution and other environmental harms are concentrated in poor communities of color (Morello-Frosch et al., 2001; Morello-Frosch and Shenassa, 2006). We collected resident responses via a once per day 7-day SMS/text messaging survey. Text messaging does not require the use of a data enabled smart phone, and is a demonstrated way to include individuals who may be locked out of more traditional forms of decision-making and has been effective for data collection in lower resource contexts, including localized data that can be used to inform interventions(Hall et al., 2015; Hoe and Grunwald, 2015). Study participants opted into the sub study from a larger health and air pollution study cohort(Johnston et al., 2021) (Collier-Oxandale et al., 2020). The sub study sought to gather granular data on daily resident experiences of air pollution and environmental hazards. Residents reported acute health symptoms and stressors, with repeat measures demonstrating what residents might report, rank, categorize, or cope with stressors. This approach can potentially support an analysis of how cumulative impacts play out in a localized community context. Text messaging (or SMS) was utilized with the goal of reducing burdens on participants from paper logs that can be labor intensive, difficult to support and can have lower compliance rates compared with electronic approaches(Green et al., 2006).

2. Methods

We employed a text messaging platform to collect daily diaries from residents living in South Los Angeles over a 7-day period. *Promotores de Salud* were trained by academic partners in recruitment and research methods. A *Promotor de Salud* is a community member who is uniquely linked to the cultural and geographic neighborhood and this local, networked approach offers a model that provides culturally accessible health education for low-income communities of color and supports changes for improved health(Pérez and Martinez, 2008; Rhodes et al., 2007). We partnered with skilled community *promotores* for recruitment starting with the larger neighborhood-based study on respiratory health and air pollution in the North University Park neighborhood in Los Angeles(Johnston et al., 2021). Any adult participant (>18 years of age) who spoke Spanish or English and had lived in the neighborhood for at least two years was eligible to opt in to participate after being enrolled in the larger air pollution study. All participants completed a baseline questionnaire. The questionnaire was administered in the participant's preferred language and included questions on sociodemographic information, race/ethnicity, sex, age, tobacco smoking history, occupation and residential history. We collected information about disease history, including diabetes, wheezing and doctor-diagnosis of asthma. Participants interested in the daily diary study were subsequently contacted via telephone by *promotores*. Participant data from the larger respiratory

health questionnaire was utilized to consider qualitative analyses of participant responses within the sub study. Consent was taken verbally over the phone and then again after they were enrolled, via the first question of the text messaging survey when the week began. All protocols, consent forms, and survey materials were approved by the University Institutional Review Board.

2.1. Study location

Sub study participants were located in the North University Park neighborhood of South Los Angeles. Residents of this neighborhood are predominantly low-income Latinx families. Over 90% of residents in the neighborhood are people of color (self-identify as Latinx/Hispanic, Black, Asian and/or as a race other than White) and approximately three-quarters of households live below 200% of the federal poverty line (Shamasunder et al., 2018). According to CalEnviroScreen, CA's environmental justice screening tool to identify highly vulnerable communities, this area is among the top 10% most disproportionately-environmentally and socially burdened areas in the state(Office of Environmental Health Hazard Assessment (OEHHA), 2016). These neighborhoods fall into the bottom 20% for educational attainment and among the top 15% for poverty based on CalEnviroScreen state level metrics. This community is zoned as mixed used with heavy industrial operations, such as oil extraction, that operate alongside residential and educational uses, and the community is also transected by major freeways (Fig. 1).

2.2. Health and air pollution cohort

A total of 89 residents were enrolled in the daily diary study and completed at least one diary entry from 303 eligible participants in the larger Health and Air Pollution study (Table 1). The larger study cohort included 971 participants, ages 5–85. This pilot sub study focused on adult residents ages 18 and older in one of the two study neighborhoods. The mean age of daily diary participants was 36 with a range of 18–70, compared to a mean of 46 years among all adult participants in the cohort. Most participants were female (79.8%) and preferred Spanish (94.4%). All participants identified as Latinx/Hispanic. The median time living in the neighborhood was 10 years and approximately half of all participants were employed outside of the home at the time of the data collection. 12 participants (13.5%) reported a doctor diagnosis of asthma while 16 participants (18%) reported diabetes. Nearly half of all participants lived within 200m of a freeway while 40% lived within

Table 1
Participant demographic characteristics.

	North University Park Cohort Adult Participants	Daily Diary Participants
	N = 303	N = 89
Age categories, N (%):		
18-<45	152 (50.2%)	52 (58.4%)
≥45	151 (49.8%)	37 (41.5%)
Gender, N (%):		
Female	213 (70.8%)	71 (79.8%)
Male	88 (29.2%)	18 (20.2%)
Race/Ethnicity, N (%):		
Black or African American	4 (1.3%)	0
Hispanic or Latinx	292 (96.4%)	89 (100%)
Multi-racial/Other	7 (2.4%)	0
Preferred Language		
English	33 (10.9%)	5 (5.6%)
Spanish	270 (89.1%)	84 (94.4%)
Employed outside of the home, N (%)	132 (43.7%)	45 (51.1%)
Duration (years) of residence in the neighborhood, Median [25th; 75th]	10.0 [5; 17]	10 [5; 18]
Ever smoker, N (%)	70 (23.1%)	19 (21.3%)
Exposed to environmental tobacco smoke at home, N (%)	28 (9.2%)	4 (4.0%)
Allergic rhinitis/Hay fever, N (%)	57 (18.8%)	14 (15.7%)
Doctor diagnosis of asthma, N (%)	32 (10.5%)	12 (13.5%)
Ever wheeze, N (%)	100 (33.1%)	34 (38.2%)
Diabetes, N (%)	53 (17.5%)	16 (18.0%)
Hypertension, N (%)	83 (27.4%)	20 (22.5%)
BMI, mean (SD)	29.09 (5.78)	28.97 (5.26)
Distance from the closest freeway, N (%):		
≥ 200m	155 (53.5%)	41 (48.8%)
< 200m	135 (46.5%)	43 (51.2%)
Distance from industrial oil site, N (%)		
≥ 200m–1000m	179 (59.1%)	53 (59.5%)
< 200m	124 (40.9%)	36 (40.5%)

200m of an industrial oil extraction site.

The participants provided a total of 521 daily responses. Seven participants completed fewer than three responses and were excluded from subsequent analyses. 55 of the 89 participants (62%) completed the entire 7-day study, while 13 participants completed 3–4 days and 14 completed between 5 and 6 days (Fig. 2). All participants received a call mid-week. Some participants would continue responses when we called, encouraged them to continue, and ensured them that their participation
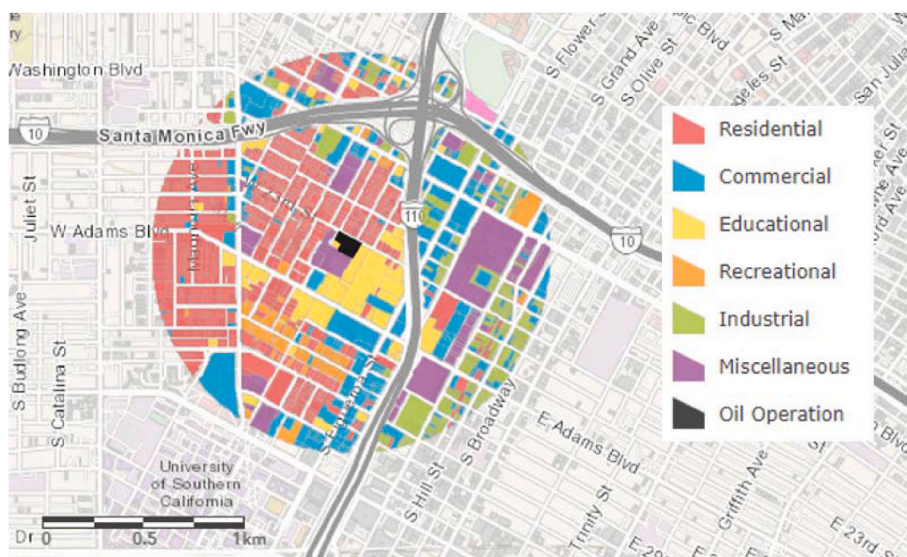

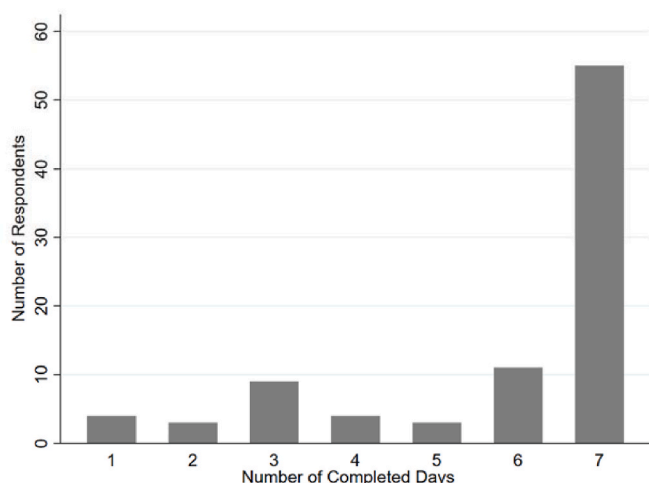**Fig. 1.** Study area, North University Park.

Fig. 2. Number of days participated.

was important to the study. However, we still see a drop off in participation as the week progresses.

2.3. Health and environment daily diary

Once enrolled in the study, participants received a daily text message for the study duration. They were asked to reply to questions about the past 24 h in three categories: environment, self-reported health, and daily stressors. The questions were developed in partnership with *promotores*, leveraging questionnaires developed with residents nearby nuisance industries.[31,32] Participants were asked to describe their overall health that day (bad, fair, good, excellent). Participants were then provided an opportunity to give reasons for their answer above through the follow-up question, "Can you describe why your health is (bad, fair, good, excellent) today?" We asked participants to report (yes/no) whether they experienced the following acute symptoms in the past 24 h: dizziness, nosebleeds, fatigue, headache, wheezing or whistling in chest, sneezing, running nose and backache. We also collected information about whether participants were currently experiencing pneumonia, bronchitis, a cold, or flu. Additionally, we collected quantitative and qualitative information about the context that many impacted their health status including: how much stress they experienced (a 5-point scale ranging from "none at all" to "a lot"), the source of their stress (a free text response), the outdoor environment (a free text response), and the presence of ambient odors (yes/no). For those who noted experiencing bad odors, they were asked, *Please describe the bad odors you noticed.* Additional open-ended questions were, *Please describe your environment today* and *In a few words, please describe your overall health today.* Participants were also asked the number of hours spent outdoors in the past 24 h, and whether they had participated in any physical activities outside during the same 24 h.

Daily diary messages were sent using the Textizen platform (a subsidiary of Granicus), a text/SMS based service used by entities such as governments, non-profit organizations, or researchers to gather public input local issues, ballot measures, health information, or other such efforts. Diaries were collected over a two-month period from April through June 2017. Residents participated over a 7-day period with a reminder prompt on day 4. Diary questions were sent to participant phone numbers daily at 6pm pacific standard time, asking the same set of questions each day. Over the two-month period, we enrolled 8 cohorts. Participants were made aware they could discontinue participation at any time. Mid-week, participants were supported through a phone call from the study coordinator to encourage completion, discuss any challenges, or answer questions. Participants could also contact the study coordinator at other times during the week. Mid-week phone calls

were included in the methods design following a trial period where we noted that some participants did not automatically reach out to the study coordinator if they had questions and some needed encouragement to continue participation around day 4. Thus, all participants received a phone call from the study coordinator mid-week.

Data Analysis. We conducted exploratory analysis of participant characteristics of the daily diary in comparison to the larger neighborhood study. Participants that completed at least 3 of the 7 days were included for subsequent analysis, a drop off measure used in other daily diary studies(White and Shih, 2012). Open response data entered by participants was transferred into a spreadsheet and analyzed through a deductive coding structure where we applied top codes and sub codes to group and sort responses. Responses were coded and analyzed for patterns within and across top and sub codes. For example, when asked to describe sources of stress, a top code may be "work" whenever mentioned as a stressor, which was inclusive of different types of work stress such as job difficulty or lack of work.

Descriptive statistics were summarized for reported health symptoms, stress, and overall reported participant health. Correlations between health symptoms and community experiences were assessed using Pearson's correlation coefficients. We assessed the within person variability in the daily responses with measures of stability and transitional probabilities if there were at least 10 responses in each group. The stability probability describes the percent of time that the participant has the specified response, conditional on the participant reported that observation at least once during the study. The transitional probability describes, for example, the probability of becoming symptomatic or asymptomatic, respectively, from one day to another for the reported acute health symptoms. Driven by the qualitative findings noting odor in the context of air quality, we also considered through a repeated measure logistic regression model with an individual random effect (*xtlogit*) to assess whether participants that reported ambient odor experienced more daily stress, (a binary category that combined some stress or higher) or whether participants that noted odors also reported wheezing. All responses were coded and statistical analyses were conducted using R statistical computing language (R Core Team, 2020) version 3.6.2 and STATA 15 IC.

3. Results

3.1. Health symptoms and activities

Most responses to the question about daily stress indicated experiencing no stress (stress = 1; 44.9%), while "a lot of stress" (stress = 5) was indicated in 14.3% of the responses. Stress levels of 1, 2, 3, and 4 were reported 18.1%, 11.6%, 11.0%, and 6.6%, respectively. In terms of general health, most responses noted good (39.0%) or fair (34.5%) health, some reported bad (3.8%) or excellent (14.3%) health. The most frequently reported health symptoms were headaches (123 responses; 24.2%) and sneezing (107; 21.0%), while the least frequently reported were nosebleeds (1; 0.2%), followed by pneumonia (3; 0.6%). The largest number of responses noted 2–3 h spent outside (36%), followed by 0–1 h (28%), and then more than 6+ hours (19%). In addition, 15.9% of the 415 responses (30 unique participants) noted adverse ambient odors.

3.2. Daily diary open ended responses: stress, health, environmental quality

Table 3 presents the main codes and the count of the codes identified through the text entry questions.

Stress. 488 responses across all participants provided information about their daily source of stress. The most common stressor was lack of physical well-being or ill health (n = 64 of 488). These included headaches (15), fatigue or tiredness (15), general ill health (9), neck pain (7), allergies (5), back pain (4), anxiety (4), body pain (3), and sleeping

Table 2

Survey responses n = 82 people. Daily Health Symptoms/Status, Stress, and Environmental Quality.

	Total Responses	Stability Probability/ Within Percent	Transitional Probability
	N = 521		
Wheezing, N (%):			
Yes	59 (11.9%)	46.0%	37.3%
No	437 (88.1%)	92.2%	3.4%
Dizziness, N (%):			
Yes	36 (7.6%)	31.0%	50.0%
No	436 (92.4%)	95.5%	3.7%
Nosebleed, N (%):			
Yes	1 (0.2%)	–	–
No	508 (99.8%)	–	–
Fatigue, N (%):			
Yes	92 (18.1%)	43.7%	42.3%
No	417 (81.9%)	85.0%	9.55%
Headache, N (%):			
Yes	123 (24.2%)	47.9%	39.1%
No	386 (75.8%)	82.0%	9.63%
Backache, N (%):			
Yes	98 (19.3%)	43.4%	40.0%
No	411 (80.7%)	86.8%	7.6%
Pneumonia, N (%):			
Yes	3 (0.6%)	–	–
No	506 (99.5%)	–	–
Bronchitis, N (%):			
Yes	10 (2.0%)	71.4%	11.1%
No	499 (98.0%)	99.5%	0.2%
Cold, N (%):			
Yes	25 (4.9%)	24.3%	57.1%
No	484 (95.1%)	96.7%	2.7%
Flu, N (%):			
Yes	38 (7.5%)	43.4%	30.0%
No	471 (92.5%)	95.5%	3.0%
Sneezing, N (%):			
Yes	107 (21.0%)	43.6%	45.3%
No	402 (79.0%)	83.9%	9.3%
Runny Nose, N (%):			
Yes	81 (15.9%)	39.3%	44.6%
No	428 (84.1%)	87.4%	7.7%
Visit Emergency Room, N (%):			
Yes	8 (1.7%)	–	–
No	462 (89.3%)	–	–
Ambient Nuisance Odors, N (%):			
Yes	66 (15.9%)	45.3%	59.2%
No	349 (84.1%)	86.5%	7.3%
Physical activity N (%):			
Yes	292 (58.2%)	68.2%	26.0%
No	209 (41.8%)	56.2%	31.0%
Stress Scale, N (%):			
1 (None at all)	216 (44.9%)	59.1%	–
2	87 (18.1%)	27.6%	–
3 (Some)	56 (11.6%)	27.5%	–
4	53 (11.0%)	32.4%	–
5 (A lot)	69 (14.3%)	26.2%	–
General Health, N (%):			
Bad	19 (3.8%)	21.7%	–
Fair	174 (34.5%)	42.4%	–
Good	197 (39.0%)	44.3%	–
Excellent	72 (14.3%)	26.1%	–
Missing	43 (8.5%)	31.9%	–

Table 3

Open question responses: Stress, health, environmental quality.

Main Code identified	Response Count
Please identify the source (if any) of your stress.	*n = 488*
Lack of physical well-being or ill health	64
Work	56
Children	24
General worries	24
School	19
Can you describe why your health is excellent?	*n = 212*
I feel good	58
Specific scenarios (slept well, ate well)	20
Activity (exercise, went to the park)	18
I don't feel sick/nothing hurts	56
Please describe the air quality today.	*n = 439*
Positive descriptors (good, very good)	156
Neutral descriptors (regular, normal)	112
Temperature/weather descriptors	93
Negative descriptors (poor, bad)	56
Please describe the bad odors you noticed.	*n = 84*
Gas	29
Smog	8
Smoke	8
Something dirty	6
Rotten	5
Chemicals	4

discouraged or hopeless (4), emotional problems (1), and inability to focus (1). Responses (24) did not specify but attributed stress to "general worries", "daily life", "personal problems". Environmental concerns (4) included crime, air quality, noise, weather, cold, and heat. 135 of 488 recorded responses noted they had no stress.

3.3. Health descriptions

Among respondents who described meanings of good health, the most frequent responses were "I feel good" (58) and "I don't feel sick/ nothing hurts" (56). Some participants provided details about good health that day such as they ate well (8), slept well (6), were able to finish tasks (2), able to take care of themselves (2), proper weight (1) and ability to work (1). Several participants connected health to emotional or mental well-being, and responses included that they were not stressed (5), optimistic or excited (3), mentally healthy (3), relaxed (2), happy (1), and had a desire to do things (1). Respondents also directly stated an activity that contributed to their good health (18) including exercise (10), going to the park (3), meditation (2), spending time with family (2), and being out in the environment (1). Participants also described health relative to the prior day including that they felt better than the day before, had allergy improvements, and that they did not have discomfort. Some respondents also highlighted that they felt better when the air did not smell like gas as much as it had in the prior days (4). Participants also mentioned physical discomforts such as not feeling well (2), allergies (3), back pain (2), and nasal congestion (1). Participants also noted physical discomforts that impact good health (7) with allergies, back pain, and nasal congestion included in challenges to good health. In addition, respondents mentioned they felt good with the absence of ill health including no headaches (6), not needing a doctor (6), no fatigue (2), no back pain (2), and no bleeding (1).

3.4. Environmental quality

3.4.1. Air pollution

When asked to describe their daily air quality participants' responses varied between good, moderate/okay, and bad. Many of the responses were positive (n = 156) and common answers included good (120), very good (17), fresh (41), and clear (4). We also noted variations across days, in those respondents who noted good air one day would note polluted air on another. Responses included better, agreeable, great, somewhat clear, and beautiful. Common neutral/moderate responses (n

problems (2). Many responses (56) cited concerns over work, including worries about work, lack of work, and housework. Worries about children were also commonly cited (n = 24) including sick children, caring for a young baby, and homework. Worries about schooling was also commonly cited (n = 19). Economic stress (n = 10) included economic problems, lack of income, bills, rent, and lack of money to purchase school supplies for children, though worries about work more generally could have included economic stress but are not double counted here. Transportation related issues (n = 15) included riding the bus and traffic. Mental health (11) stressors included anxiety (6), feeling

= 112) included regular/normal (52), more or less (24), okay or fine (12), fair (11), and responses that nothing was out of the ordinary (4). Participants highlighted poor daily air quality (n = 56), and responses included bad (13), poor (12), polluted or contaminated (9), a little contaminated (3), very contaminated (1), and not good (1). Others said that the air smelled like gas (5) and described the quality as heavy, thick, dry, and blurred. Some participants described the air quality in terms of temperature or weather. Responses included cold (16), hot (14), breezy or windy (7), very hot (2), humid (4), gloomy (1), and foggy (1).

3.4.2. Odors

The most frequently described ambient odor was gas (29), followed by smog (8) and smoke (8). Other frequent responses were something dirty (6), rotten (5), chemicals (4), drainage (4), oil (3), stench (3), and strange (3). Responses that were recorded a single time included petroleum, burned, burning tires, waste, intense, marijuana, bad, strong, like not being able to breathe, and I don't know how to describe.

4. Reported symptoms and stress

We examined correlations between exposures with Pearson's correlation coefficients ranging from −0.292 to 0.381 (Fig. 3). Significant positive correlations were reported between resident experiences and health symptoms including headache and stress ($\rho = 0.355$, $p < 0.05$). Other significant correlations were reported for odors and backache ($\rho = 0.415$), bronchitis and wheezing/whistling ($\rho = 0.381$) and backache and wheezing/whistling ($\rho = 0.369$). The correlation also presented significant positive associations between bad odor and a range of health symptoms and outcomes notably stress ($\rho = 0.346$), sneezing ($\rho = 0.335$), and running nose ($\rho = 0.257$, $p < 0.05$). no ambient odors.

5. Daily response variability

From the yes/no health symptom questions (e.g., wheezing, dizziness, nosebleed), responses were more variable across days among respondents who reported experiencing the health symptom (Table 2). For the 59 responses that reported wheezing in at least one of their responses, 46.0% of their responses were "yes" to wheezing. In

comparison, for the 437 responses that reported no wheezing, 92.2% of their responses were "no". Headaches were found to have the least variability among the responses reporting "no" (47.9%). Of those who reported health symptoms, the highest probability of becoming asymptomatic was among those who reported sneezing at least once (45.3%) and the lowest probability was among those experiencing bronchitis (11.1%). Respondents that reported a lot of stress (24%) also demonstrated more variability than those who reported no stress (59.1%), with the possibility that stressors, and reports from those stressors, can vary day to day. Variability in responses were also reported regarding ambient odor between days and for the 66 responses noting yes to smelling odors, 45.3% of their responses were "yes". While for the 349 responses reporting no ambient odors, 86.5% of their responses were "no". The transitional probability for those reporting ambient odors was 59.2% compared to 7.3% for those reporting. Based on the results reporting ambient odors of gas and demonstrating evidence of variability in both reported odors and associations with health symptoms, we conducted a sub analysis evaluating whether those who noted bad odors also noted stress.

6. Odor/stress sub analysis – Stress causes

Among respondents, reporting stress (defined as a score of 2 or greater) occurred in 37% responses. Bad odors were reported 66 times from 30 unique study participants. The odds of reporting stress on the day where bad odors were experienced was on average 6.2 (95% CI: 2.64–14.6) times reporting stress on days where bad odors were not reported (Fig. 3). The patterns hold when adjusting for time spent outdoors. We conducted a similar analysis examining the association between wheeze and stress and found similar results. Among days where respondents reported wheezing, we found the odds of reporting a higher stress day was 5.1 (95% CI: 1.77–14.72) compared to days with no wheezing.

7. Community report back

Results from this pilot study were incorporated in the larger report back to participants within the health and air pollution study. The research team, including the *promotora de salud* team jointly considered results and translated these into meeting and outreach materials. We held two community meetings in English and Spanish and results were also shared and posted in both languages via an infographic(Johnston et al., 2021; USC Environmental Health Centers, n.d.).

8. Discussion

Environmental justice communities have argued that existing research and related regulatory strategies do not adequately capture on the ground neighborhood realities, including illness, psychosocial stress, and exposures from multiple pollutants (Pulido et al., 2016; Richter, 2018). Research approaches have followed in an effort to better incorporate multiple, cumulative, and synergistic burdens faced by low income communities of color(Cushing et al., 2015; Solomon et al., 2016). Still, the clustering of pollution and socioeconomic vulnerabilities in environmental justice neighborhoods creates challenges for disciplines such as epidemiology that typically aim to isolate exposure and outcome (Wing, 1998). Qualitative research can provide important contributions to environmental health and justice research(Hoover et al., 2015), but there are few sustained or viable approaches to incorporate such data gathering that could systematically integrate open-ended responses to examine co-occurrences of stressors, environmental quality, and health outcomes at the neighborhood scale. Thus, the systematic inclusion of mixed methods approaches within existing epidemiological and other study designs can improve collection of contextual, personal experiences of health and environment. The mobile daily diary presents one option for incorporating resident self-reported information and gathering
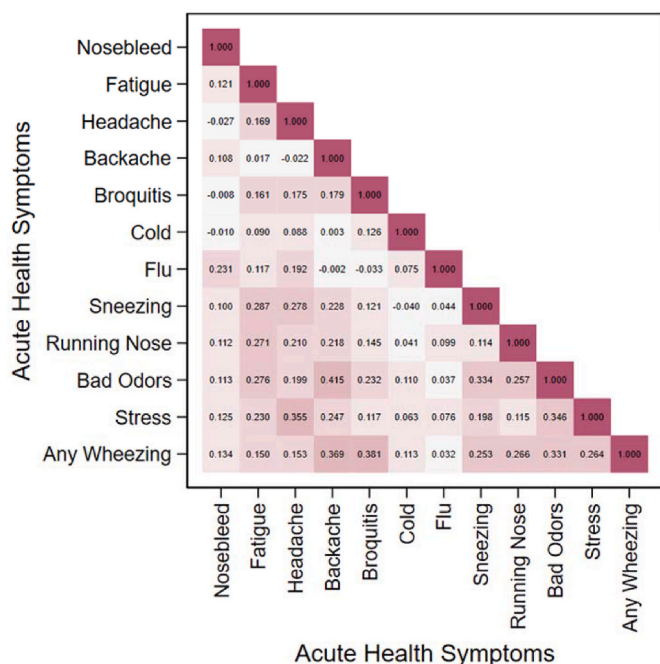
Fig. 3. Correlation matrix of health symptoms, stress, and odors. The intensity of the color indicates the magnitude of Pearson's Correlation Coefficients.

contextual responses into ongoing exposure or epidemiology studies, as well as a way for agencies and other regulatory entities to include resident input into decision-making.

As a part of a larger health and air pollution study in South Los Angeles, this pilot study sought to examine whether and how participants might experience health and environment in a cumulatively burdened context. South Los Angeles is documented by the California Environmental Protection Agency to be in the top 5% of most heavily burdened communities in the state. While spatially identified through CalEnviroScreen, there has been limited information as to how residents describe health and air pollution as a part of day-to-day living, including whether there is variability in these experiences. Daily documentation with participants can be difficult with few tested methods. Daily diaries have been used in prior environmental justice studies, through paper logs, but these can be time intensive, and difficult to collect and analyze. Here, we tested the feasibility of using mobile daily diaries in a mixed methods format, gathering both numerical and open-ended data. We find that mobile daily diaries are a feasible method for assessing within person variability in daily responses, and that residents do respond and show compliance in this format. Participants also added open-ended, textual responses to the daily dairy, providing important contextual information. This combination provides a data richness not captured through numerical data alone.

Mobile or SMS queries have been primarily used to gauge resident support for single decisions(Desouza and Bhagwatwar, 2014), or documentation for symptoms from an illness diagnosis. For example, a three-month daily diary study of Hispanic children with asthma in a Los Angeles community proximate to high-density freeways reported positive associations between asthma symptoms and criteria pollutants and volatile organic compounds(Delfino Ralph J et al., 2003). There is more widespread use of daily diaries for in psychological research. For example, diaries have been utilized to capture daily anxiety and depressive symptoms, document a link between stress and mood/anxiety disorder symptoms(Carl et al., 2014), and examine the relationship between daily discrimination and depressive symptoms(Torres and Ong, 2010). Daily diary methods in other contexts with vulnerable groups have shown within-person associations and day-to-day changes based on the participant's interactions within their community or environment. In a study of daily minority stress on gay and bisexual men, researchers found support for conceptualizing minority stress as a within-person, time-varying experience that was more meaningful than comparison between individuals. In addition, the SMS daily diary has been effective in low resource and non-Western cultures. A daily diary study in Pakistan collected everyday life symptoms that are not typically captured, can be transient in nature, and are typically managed outside of the healthcare system through self-care or home remedies (Anwar et al., 2017). In predominantly low-resourced and immigrant communities in the US, these findings may have resonance. In our study, we also found within-person variability in health symptoms across days and were able to identify co-occurrences of stress and acute health symptoms, as respondents that noted higher levels of stress also reported more experiences of bad odors. In consideration of day-to-day variability in environmental quality, prior research has shown that people adjust daily activities in response to and as a defensive action against air pollution experiences(Bresnahan et al., 1997). Thus, a mobile daily diary approach may be a more facile way to examine relationships between stress and environmental conditions (e.g., air quality or odors), and ways that residents may cope with these experiences. We did not ask questions about coping or self-care, though these would be helpful to include in future research.

Daily symptoms are less understood compared to symptoms related to chronic health outcomes. Health symptoms may also be an indicator of chronic illnesses, so capturing daily nuisance symptoms may be important for a variety of health screening or surveillance programs. Daily diaries also reduce recall bias and improve accuracy in recording individual behaviors.

Odors are notable contributors to quality of life and can be transient. Daily diaries have highlighted resident experiences and health symptoms connected to odors from industrial and animal operations. One study in an environmental justice community near a landfill in North Carolina found that reported odor increased for every 1 part per billion (ppb) increase in hourly average hydrogen sulfide (H_2S) measured(Wing et al., 2008a). Odor was also strongly associated with reported changes in daily activities and a range of health symptoms and psychological effects, with reported positive associations between reported odor and H_2S(Heaney et al., 2011). Studies have also reported community-level experiences with odor on a very localized scale. An urban study in New Jersey found odors to exceed the threshold of nuisance as defined by the state, with a distinct pattern of spatial variability in the type, intensity, and concentration of odors from industrial activities at the neighborhood scale(Kitson et al., 2019). Our study found that some residents report bad odors as an experience of their environment, and there was a positive correlation between those who reported odors and increased stress. Our results suggest nuanced daily experiences of environmental quality such as odor and air pollution and changes in acute symptom experiences. Future research might refine this approach in order to better understand whether adverse health experiences might heighten experiences of polluted environments, or vice versa.

While daily diaries can capture day-to-day changes in participant responses, limitations include a burden on participants that can result in loss to follow up or incomplete diaries. When used, paper diaries may be lost or difficult to read. Mobile daily diaries could address these limitations and may improve ease and efficiency for both participants and researchers. One study measured reported versus actual compliance of paper diaries and electronic diaries and demonstrated higher compliance in the electronic diary group compared to the paper diary group (Carl et al., 2014).This study also reported a significant decline in paper diary compliance compared to a negligible decline in electronic compliance. In our study, approximately 7% of the participants responded to less than three days of the survey and were considered lost to follow up, presenting evidence that texting may be a viable method for daily diaries with higher compliance, and(Eldahan et al., 2016). Our study combines some of these approaches by using electronic, mobile platforms with widely accessible text messaging to document health and environment experiences, without a focus on a specific illness diagnosis, in an environmental justice community. As a pilot study, we found feasibility for this approach, though it would be important to integrate these methods into future study designs in a larger scale, to gather mixed methods data over time. Our results demonstrate that participants do respond to daily diary message prompts, with some encouragement beneficial mid study, and participants showed variability of responses over the 7-day period, as they reported different types of stressors, air quality experiences, and health symptoms.

In particular, this approach might help support innovations to traditional epidemiological methods that can be hampered in multiply burdened contexts. Traditional epidemiologic studies focus on between-person associations and these methods are often difficult to implement in communities that face cumulative environmental and social stressors (Wing, 1998). The daily diary method has been shown to be particularly well suited to capture daily stress, emotions, and health symptoms (Gunthert and Wenze, 2012). Everyday stressors can garner less attention than stress stemming from disasters or major life events, but there is growing evidence that household or community level aggravations provide a better overall picture of individual stress, including difficulties in negotiating day-to-day life(Monroe, 1983). Thus, the ability to gather and analyze everyday stressors can be beneficial to environmental health research in environmental justice communities. The cumulative effect of negative reactions to daily minor challenges can create vulnerability to health challenges and have adverse psychological impacts(Massey et al., 2009). Intrinsic stressors can combine with extrinsic stressors such as work or concerns over children's schooling or safety and may contribute to worsened health outcomes or quality of life.

However, there remain limitations to the daily diary approach. For example, we document a correlation between stress and odors, but we cannot determine the causal direction of this relationship. This can possibly limit interventions that might be derived from this analysis and might be the focus of future research.

9. Conclusion

Cumulative burdens faced by environmental justice communities can structure health outcomes and life chances for residents(Morello-Frosch et al., 2011). Screening tools such as CalEnviroScreen have helped identify the distribution of harm across cities, regions, and states. Less well understood are the daily experiences of living nearby polluting industries and freeways, while navigating daily life such as work, schooling, and lack of resources. Residents grapple with air quality, odors around their homes, and make decisions such as how much time to spend each day outdoors. Mobile daily diaries can be one way to capture variable responses to environmental quality, acute health symptoms, and stressors. We find that residents in environmental justice communities record variation in their daily diary responses and document changes in environmental quality, stressors, and odors. Refining this type of method could enable a more rigorous examination of co-occurrences of environmental quality and acute health symptoms. The inclusion of iterative qualitative data within mixed methods designs is also one potential strategy to address limitations in traditional epidemiological methods in cumulatively burdened contexts. This approach can be used in community-based research studies with questions designed in collaboration with affected residents. Used with measured data such as air monitoring or health measures such as lung function, these mixed methods approaches can be utilized in efforts to alleviate sources of daily stress, alongside efforts to reduce overall pollution burdens.

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