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The Census of Social Institutions (CSI):

A public health direct observation measure of local land use

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Abstract

This manuscript describes the development of the Census of Social Institutions (CSI), a reliable direct observation parcel-level built environment measure. The CSI was used to measure all non-residential parcels (n=10,842) in 21 one-mile-radius neighborhoods centered around census block groups of varying income and ethnicity in a large metropolitan area. One year test-retest intra-class correlations showed high reliability for Major Use Type and Detailcode observations. The CSI accurately captured the presence of about 9,500 uses, including 828 Multiple Major Use and 431 Mixed Major Use parcels that would have been missed in standard commercial databases. CSI data can be utilized to determine the health impacts of environmental settings.

Audits of the built environment are increasingly used to understand the influence of street-scale variables on health.[1-8] Ecological models of health behaviors, which include demographic, biological, psychological, social, cultural and environmental factors, suggest it is more efficient to enhance environments to improve people's health rather than primarily focusing on individual-level interventions such as dieting or exercise programs, because environmental enhancements can simultaneously improve individual and population health.[9-10] The environment can exert broad influence on health by both constraining some behaviors and encouraging others.[11-12] This paper describes a novel direct observation tool developed to measure the built environment. The Census of Social Institutions (CSI) is a comprehensive, parcel-level assessment of the full range of non-residential parcel land uses.

From a social-ecological perspective, there is long-standing theoretical justification to study physical environments that surround individual choices.[13] As individuals navigate their daily lives, they engage in complex transactions with multiple levels of the environment. Increasingly, health promotion disciplines are attending more closely to the interplay between the built environment and health, employing related terminologies[14-15] to refer to the disease-facilitating influences of geographic elements,[16] e.g., the "toxic environment" for obesity.[17] In fact, environmental influences are those standing between large-scale forces such as income inequalities and behavioral patterns such as food consumption and physical activity.[15,18]

Macro-scale institutions such as alcohol, tobacco, lending, and food industries manifest as pivotal elements in the urban and rural institutional environment,[19-21] resulting in varying concentrations or availabilities of goods and services.[22] From an ecological perspective negative health effects stemming from settings that promote unhealthy behaviors, such as alcohol, tobacco or fast food outlets, might be balanced by the presence of health-promoting institutions like full service supermarkets, playgrounds, movie theaters, or parks.[23] However, in order to examine putative impacts on health, such studies require accurate, fine-grained detection of existing institutional land uses at the lowest possible level of aggregation. To advance research on connections between built forms in communities, sound measures of both single institutional representations and the mix of institutions at the parcel level in communities need to be in place, but such measures are lacking.[1,3,15,24]

Measurement of environmental attributes has presented important research challenges, including debate over the accuracy of pre-existing databases that may not reflect actual conditions or that may obscure key empirical relationships.[25] A review by Booth et al.[1] of the extant literature found that while there was support for a strong relationship between obesity and the built environment, the evidence base was incomplete due to the absence of studies employing direct measurements of institutional presence. They concluded that measures often relied on proxies derived from census data; or when based on other secondary sources, the data were incomplete or not comparable across jurisdictions.

In an earlier analysis of 31 instruments originating from multiple disciplines, Moudon and Lee[3] concluded that primary observational data on spatiophysical variables were needed as well as more fine-grained measures at the micro-scale. Two more recent reviews also noted weakness of findings attributable to use of secondary data or data aggregated at too high a level of analysis (e.g., zip code or census tract), emphasizing the need for reliable direct observation instruments.[18,24] Large-scale Geographic Information Systems (GIS) studies often have sources of error that should be accounted for in analyses.[25] Typical errors include incomplete data, inaccurate classifications for facilities or their characteristics, or inaccurately geocoded locations. One study comparing a commercial database of recreation facilities with field observations found that the commercial database undercounted the facilities with the main sources of error being 1) facilities included in the commercial database but not found in the field, 2) facilities included in the commercial database but not classified correctly in the field, and 3) facilities identified in the field but not included in the commercial database.[25]

Many studies employ indirect or proxy measures such as census data, self-reports, commercially available databases, or secondary land use data.[22,26-31] Some investigations have focused on what are generally considered to be desirable (e.g., parks or playgrounds) or undesirable (e.g., abandoned buildings) institutions in a given geography, but these studies utilized census tract-level data or secondary data on land-use mix.[32-33] An early exception was a direct observation approach developed Raudenbush and Sampson[34] based on analyses of videotapes of streetscapes recorded from automobiles. This methodology allowed for direct observation at the face block level to collect data on neighborhood social and physical disorder.

Several other studies have employed direct observations predominantly focused on features of physical activity-related resources, such as walking or cycling environments or worksites and their immediate environmental contexts.[8,35-39] Three reliable direct audit measures explicitly incorporated a broader range of built environment forms, including the Irvine-Minnesota Inventory (assesses accessibility, pleasureability, and perceived safety from traffic and crime), a community analytic and checklist audit tool (assesses land use, transportation, facilities, aesthetics, signage, and the social environment), and the neighborhood observational checklist (assesses neighborhood social disorganization through land use, building and grounds conditions, establishments, ethnic symbols and services, and signs).[40-42] However, the principal limitation of these instruments is that they used street segments, not parcels (i.e., legal units into which property is divided for sale and purchase), as their observation unit, which resulted in a lack of depth in the amount of detail that was collected about the built environment. Another consequence is that the number or combination of possible uses per observation was restricted. The direct observation instrument described in the present study addresses these issues using an electronic format that yields both quantitative and qualitative data at the parcel level and does not restrict the number of uses for each parcel.

Spatially, parcel-level data provide disaggregated information that is the most flexible for matching data to multiple study area boundaries and for spatial analyses. Rather than focusing narrowly on a single type of use or institution, the CSI quickly catalogues all non-residential parcels' uses and their conditions. The CSI has the unique capacity of noting multiple or mixed uses within establishments or parcels and allows for aggregating parcels with certain characteristics in portions of street segments and relating these to individual and group outcomes in a form that can be utilized in various health research areas (e.g., obesity, tobacco, physical activity). The purposes of this paper are to describe the development of the CSI and to analyze the reliability of the instrument with reference to general and specific categories of local institutions.

METHODS

Study Design

The CSI was developed as part of a larger multi-level study of environmental risk factors thought to contribute to obesity prevalence, the Kansas City Built Environment and Health Study (KC BEST). KC BEST specifically examined relationships between health and health-related variables, taking into account socioeconomic status (SES) and actual characteristics of the built environment. KC BEST employed a cross-sectional three-group nested design in a five-county region that comprised the greater Kansas City (Missouri and Kansas) metropolitan area. For the nested design, identifiable groups were randomly selected to populate study conditions rather than individual participants.[43] The grouping factor for the study was median yearly family household income. Census block groups were divided into tertiles based on the population distribution of household income. Census block groups were chosen as the basis for selection because of their relatively low level of geographic aggregation.

By necessity, the analyses were based on the 2000 census. We excluded census blocks with few residents (i.e., mostly businesses and populations of less than 400), leaving over 325 census block groups for potential inclusion. Income tertiles contained at least 325 potential census block groups. Income tertiles were defined as low ($4,999.00 to $23,386.33), middle ($23,386.34 to $35,569.00), and high ($35,569.01 to $150,001.00). We used the following three inclusion criteria in the selection process: 1) census block groups were within one standard deviation of the income tertile group's average median household income; 2) no contiguous census block groups were selected to help ensure independence of environmental data; and 3) at least 19% of residents in each of the census block were from an ethnic minority group. Once all available census blocks were identified based on the income criteria, seven census block groups were randomly selected for inclusion in the study for each household income level, for a total of 21 total census block groups. Overall, data were gathered from parcel-level direct assessments of 10,211 street segments covering 56.52 square miles across five metropolitan counties.

Measure Development

We searched for and detected no direct observation instrument that would yield parcel-level detailed data for the entire non-residential built environment in a given geographic area. Although various public and private data sources such as city directories or commercially available databases were available, most were aggregated at too high a level of analysis, or did not reflect multiple uses within a given establishment or parcel. We investigated the use of zoning or land-use data from municipalities or counties for this study; however, the myriad of land-use and zoning schemes used by public or private entities (e.g., state, local, or municipal planning authorities, American Planning Association) were highly variable and thus not useful for our study that crossed several jurisdictional boundaries. Even within jurisdictions, land-use categories often overlapped or lacked the specificity necessary to distinguish between commercial entities of the same broad category (e.g., commercial institutions such as a dry cleaner, a fast-food restaurant or a pharmacy with an ATM). Therefore, we developed a new instrument, the CSI, to gather disaggregated parcel-level data necessary for fitting GIS tracking and analyses to our 21 study area boundaries.

We chose the term "census" in the CSI to represent the full range of built, non-residential environments, including all built forms of commercial or industrial establishments, public or civic enterprises, parks, and mixed forms – all at the parcel scale. Existing property tax land parcel shapefiles were obtained from the respective municipalities involved in the study and were imported into ArcGIS. The CSI enabled geographic overlay of each institutional occurrence (e.g., commercial, industrial) with other ArcGIS data layers (e.g., housing conditions, crime, physical health) as well as enabling additional spatial statistics applications. The CSI was used to specify a given parcel's major use and then, taking the description to a detailed level, code existing specific single, multiple, or mixed major detailed uses.

CSI data were collected electronically using hand-held computer devices. The coding scheme was developed to be compatible with US Census Standard Industrial Codes (SIC), now North American Industry Classification System (NAICS; http://www.census.gov/epcd/www/naics.html). Similar to the NAICS list, the CSI was used to identify broad *Major Use Types* – principal land use (e.g., commercial) and subsequent *Categories* (e.g., retail trade) and *Subcategories* (e.g., financial institutions). However, the CSI was also able to code at the micro-level using *Detailcodes*, and could identify single (e.g., credit union) or multiple detailed uses within parcels (e.g., the CSI could be used to distinguish between a "stand-alone" convenience store and one that also sold gasoline and liquor, and had a deli, an ATM, and a money transfer operation). The CSI included over 420 separate use codes, with many more uses in combination. Additional *Detailcodes* may be added by any user to customize for a given research application. (See Table 1 for list of codes.)

The CSI also differed in two other important ways from the NAICS list. First, the CSI was developed as a parcel-based, GIS-linked observation procedure that could be tailored to any geographic area where parcel files were available. Second, the CSI recorded a mix of major use types within the same parcel (e.g., commercial and public commons: public park with a concession stand) using *Major Use Type, Category*, or *Subcategory*. In the urban environments of our study, multiple use (i.e., more than one use of the same major type – all commercial uses: grocery store with an ATM and a deli) and mixed major use parcels (i.e., more than one use of different major types – commercial and industrial uses: a bakery with a warehouse) were frequently encountered, and it was important to fully capture the richness of available settings. For instance, observers encountered a large *Mixed Major Use* parcel with a private law firm, a diagnostic imaging facility, a real estate sales office, a coffee shop, and a public library (See lower portion of Table 1). Using the CSI, the record for the parcel was assigned numeric codes for multiple *Major Use Types, Categories, Subcategories and Detailcodes,* accurately capturing all of these uses.

Insert Table 1 Here

CSI Details

After selecting the correct area, street, block, and parcel number, and prior to collecting use data, the CSI was used to verify or correct each parcel's street address (if visible). Then, the Major Use Type was selected from the following options:

1. **Residential non-residential use –** built as a residence, but had a non-residential use (e.g., home daycare, office)
2. **Commercial –**retail or commercial use
3. **Industrial –**light/heavy industrial use
4. **Community institutional –**Civic/public/private institutions (e.g., schools, places of worship, libraries, government offices, fire stations, charitable institutions, community health or social services)
5. **Public commons –** parks, plazas, and other public spaces (e.g., playgrounds)
6. **Residential commons –** private park, field, or other green space
7. **Parking –** surface/structured parking
8. **Vacant lot** (non-residential) **–** no principal, classifiable structure exists on the parcel, but its apparent intended use is non-residential
9. **Vacant building –** unable to determine use of building because of vacant state
10. **Miscellaneous –** structure type does not conform to any specified class
11. **Under construction –** site is under construction
12. **Mixed Major Use –** a combination of two or more of the above major types.

Then, the number of buildings on each parcel was counted and the structure profile (i.e., number of building stories) was selected.

Although not the focus of this reliability study, the CSI was used to record physical conditions that were rated for three categories: structure, grounds, and public infrastructure. Structure conditions included building storefronts/facades that were rated on a five point scale from severely deteriorated to excellent. Operational definitions included descriptions of structural soundness, paint, windows, doors, and graffiti. Grounds conditions included litter and trash and improved surfaces that were rated on a five point scale from severe problem/severely deteriorated to excellent. Operational definitions included the amount of litter and trash and the percentage of surfaces that were cracked or broken. Public infrastructure ratings were also assessed on a five point scale from severely deteriorated to excellent for public sidewalks and catch basins, while the number of functional public streetlights on the parcel was counted.

After indicating whether the parcel itself had an overall name (e.g., Smith's Retail Plaza; Memorial Sports Complex, Central Park), individual establishment(s) name(s) were noted and all relevant detailed use codes were assigned. Codes were assigned in sequential order for the parcel's use(s) and included *Major Use Type*, *Category*, *Subcategory*, and *Detailcode,* with each selection dictating the potential choices for the next coding level on a drop-down menu. Multiple *Categories*, *Subcategories*, and *Detailcodes* also were assigned as appropriate, depending on the number of intended uses for a particular parcel and whether they were of a single Major Use type (i.e., *Multiple Use*) or of more than one Major Use type (i.e., *Mixed Major Use*). These parcels were then labeled with multiple *Detailcodes* to capture all intended uses.

An example of screens for coding a single use and a multiple use commercial parcel are shown in Figure 1, relying on the code categories in Table 1. In this example the single use parcel, a fast food restaurant (Wendy's) was coded: *Major Use Type* = 2 Commercial; *Category* = 250 Retail Trade; *Subcategory* = 2580 Eating and Drinking Estabs.; *Detailcode* = 25814 Fast food restaurant. The second screenshot shows a multiple use commercial parcel (Fred's Auto and Tattoo Shop), that was first coded as *Primary Detailcode* = 29991 Multiple commercial use. The third and fourth subsequent coding screens were used to code *Category* = 270 Services; *Subcategory* = 2750 Automotive Services *Detailcode* = 27538 General auto repair shop. An additional screen (not shown) was used to code *Category* = 270 Services; *Subcategory* = 2720 Personal Services *Detailcode* = 27233 Tattoo Parlor. The hierarchical structure of the coding scheme enabled upward and downward identification, coding and analyses of each parcel's data across *Major Use Types, Categories, Subcategories*, and *Detailcodes.*

Insert Figure 1 Here

Procedure

For each of the 21 block groups, the geographic centroid was located and the CSI was conducted for each non-residential parcel within a one-mile radius of the centroid. A one-mile radius, as used in other studies, was chosen as a proxy for neighborhood and to approximate frequently traveled areas for block group residents.[44-45] Prior to conducting the CSI in a given study area, each of 67,100 residential parcels in the 21 areas and one-mile buffers was identified and observed using a residential conditions measure (not part of the present study). Printed parcel maps were used to guide observation teams and to ensure that all parcels within each one-mile buffer were observed. The CSI also allowed for correcting parcel-level postal addresses and for correcting parcel geography (e.g., modifying a parcel footprint, adding a parcel, combining parcels) to match actual parcel characteristics.

Prior to field data collection, all data collectors were trained over a three-day period in the use of the hand-held computer devices, definitions of CSI terms (e.g., parcel ID, field address) and the use of parcel maps. First, a two-hour, interactive power point presentation was used to familiarize data collectors with environmental data collection and CSI procedures. Next, observers were carefully trained in the use of the four CSI code categories, i.e., *Major Use Type*, *Category*, *Subcategory*, and *Detailcodes*, as well as procedures for driving to assigned areas and maximizing safety. Data collectors then completed two trial data collection efforts in one community training area.

To collect CSI data, teams of three data collectors coded parcels in a systematic fashion, focusing on one neighborhood at a time. In addition to the handheld computers, each team was provided a cellular telephone, magnetic automobile signs, safety vests, driving maps, and letters of explanation for anyone who might approach the team. Each one-mile radius neighborhood was divided into seven rectangular sector maps, with a minimum of two overlapping blocks per sector. Each sector was divided into street segments, and CSI observations were guided by parcel identifiers and street/postal addresses. Each street segment was assigned a unique identifier that was linked to its corresponding hundred block and street name (e.g., 2600 Main St.). Paper maps, aligned with the geocoded electronic data, helped observers identify each segment and its corresponding parcels. Only those parcels within each CSI neighborhood or that were intersected or bisected by an area's circumference were coded. (All training materials, CSI codebooks, and electronic application are available from the authors.).

After driving each street segment to assess safety and the presence of any unmapped parcels, observations were conducted on foot. Two handheld computers were utilized by each team, one containing odd numbered postal addresses and the other containing even numbered addresses. In consultation with team members, each parcel was coded for M*ajor Use Type*; *Category*, *Subcategory* and *Detailcode(s).* One member of the team recorded data for a given parcel and orally confirmed what codes were recorded. Before leaving each parcel, all codes were reviewed and a qualitative data form was completed, if necessary.

In order to ensure that each area was observed and coded in its entirety, a data verification procedure was implemented. Areas that contained missing or conflicting information (e.g., multiple use parcel with only one detail code) were surveyed a second time. Quality control procedures were developed to ensure that surveyors accurately recorded all visible parcel uses and that the data were consistent with screen options. The present reliability analyses addressed consistency of observations over a one-year interval.

Statistical Analyses

A total of 1,093 observations for repeat assessments from across all 21 areas were examined. This represented a 10% simple random subsample of all 10,849 parcels (with a non-residential use) assessed using the CSI within the 21 Census Block Groups and the one-mile radius from its centroid. Repeat observations were conducted one year after the initial observation and coding of an area. Intraclass correlations (ICCs) were computed between the two sets of observations for Major Type and Detailcodes. One-way random effects models were examined as the primary analysis, but we also examined ICCs for two-way mixed and random effects models for comparison. One-way random effects models were selected as the primary method for computing ICCs for CSI Major Use Type and Detailcodes because the data were polychotomous ordinal (calculating reliabilities for Category and Subcategory would have been redundant, given the hierarchical nature of the coding scheme built into the coding program). We decided to use one-way random effects models because we had over 25 different observers evaluating parcels in the selected areas at both the baseline and one-year re-evaluation due to staff turnover. Given this approach, there is no reason to believe that any of the ratings could be associated with a particular rater or that variability due to specific raters could be assessed. Thus, one-way models, which combine variability due to raters, interactions between raters and the objects rated, and measurement error into within person variability,[46] were the most appropriate method for computing ICCs. All statistical analyses were conducted using SPSS 16.0.

RESULTS

Of the 10,842 non-residential parcels, vacant lots/buildings (65.3%, n = 7,083) were the most frequent Major Use Type followed by commercial (12.0%, n = 1,949); see Table 2. Multiple uses were found for 11.6% (n = 1,259) of the parcels, including 431 (4.0%) Mixed Major Use parcels. Per neighborhood, the number of Multiple Major Use parcels ranged from 5-138 (mean = 39.4) and Mixed Major Use parcels ranged from 2-68 (mean = 20.5) (data not shown).

Insert Table 2 Here

Table 3 presents the ICCs for the one-year test-retest Major Use Type, and primary Detailcode. The ICC represents the proportion of total variance accounted for by the variability between audited parcels rather than the variability within them. As shown, ICCs for all CSI ratings were uniformly high despite the one year period between ratings. In addition, all ICC were significantly different from 0 ($p<0.001$), with F-test values ranging from 4.5 to 4.8. Even if it was assumed that our data met the requirements for two-way ICC models (i.e., we had reason to assume ratings could be associated with particular raters), Table 3 demonstrates that the ICCs would essentially be the same as for our one-way models.

Insert Table 3 Here

DISCUSSION

In this paper we have described the CSI, a direct observation tool for comprehensive assessments of non-residential parcel-level land uses and conditions. Overall, the CSI Major Use Type and Detailcode observations demonstrated robust test-retest reliability. Given the number of staff involved in the study (i.e., over 25) and the one-year period between ratings, it is remarkable that Major Use Type and Detailcode ICCs were so high. This high level of rater agreement over such a long period of time demonstrates that the CSI is a reliable and valuable tool for assessing institutions at the parcel geography level. Noteworthy, is that the CSI reliably detected a substantial percentage of multiple uses within given establishments. These disaggregated data are useful for spatial analysis and can be used to match data to multiple study area boundaries and fully capture multiple and mixed major uses located on singular parcels, thus providing data useful for a variety of health research areas when combined with individual level data or census characteristics.

CSI data provide information on environmental factors that can help inform studies using the ecological model.[11-12] These data help provide information on the disease-facilitating or health-promoting influence of geographic elements.[13] In fact, the potential concentrations of unhealthy (e.g., fast food restaurants, bars, predatory lenders) or potentially health-promoting institutions (e.g., parks, fitness centers, full service grocery stores, farmers markets) might have compounding health impacts.[23] In addition, the CSI provides reliable and detailed information about the multiple and mixed uses available as behavior settings within a single parcel that can increase the likelihood of visiting the parcel due to the variety of institutions that are represented there. For example, residents might visit a certain parcel because they can get a haircut, pick up groceries, secure liquor or tobacco and mail a letter all in one stop. The 1,259 parcels with multiple and mixed uses in our study would have been mis-coded with instruments that capture only a single use per parcel, under-representing their true intended uses.

The development of the CSI directly addresses the concerns of Booth et al.[1] by employing direct measurements of the presence of institutions that can be compared across jurisdictions. The CSI also provides needed primary observation data on spatiophysical variables at the micro scale.[3] CSI data are reliable and provide necessary disaggregated data as called for by Black and Macinko[18] and Papas et al.[24] The use of direct measurements also helps correct for geocoding errors that have been found with commercial databases and can be used to assess the accuracy of these databases since they are so commonly used in studies examining the effect of the built environment on health.

While the CSI is not the first direct observation measure, it takes considerably less time to complete assessments than methods using videotapes.[34] The utility of using handheld computers for data collection helps reduce missing data, improve data quality, reduce data processing time and costs, and enhance research capacity.[47] The CSI also codes for a wider range of uses than measures focused solely on physical activity resources and their surrounding contexts.[8,35-39] At the same time, the CSI codes these uses at the smaller parcel level as compared to previous environmental measures that used street segments as their unit of observation.[40-42]

The CSI is limited by the same factors that limit all direct observation measures. The staffing required to conduct parcel-level observations can be prohibitive from both a cost and personnel perspective. However, we believe that using an electronic measure like the CSI on random subsets of geographic areas to determine the accuracy of existing databases would be an appropriate and important use when lack of sufficient funding or personnel to conduct full-scale direct observations are an issue. Even when used at the metropolitan scale in our study, we were encouraged at how observers quickly learned use of both the handheld and its protocol. Our reliability findings show that it is now reasonable to expect parcel-level accuracy in audits of physical environments. Depending on what might be required for a particular research question, parcel-level data may be aggregated to higher levels of analysis (e.g., street corner, census block group). Alternatively, subsets of institutions, say food and liquor outlets, could be clustered within a given area to examine relationships with health variables. It is, of course, an empirical matter as to whether different use combinations might be detrimental or salutary with respect to specific health variables or that parcel-level data would yield better understanding of complex environment-behavior relations. A recent review of food deserts noted the importance of accounting for context in studies of this phenomenon.[48] While the authors were more concerned about cross-country context differences, the same logic might apply within a given country or region with respect to rural-urban differences or comparisons of contexts within an urban area. For instance, a specific location might lack access to healthy foods, yet there may also be an abundance of tobacco outlets, parks, religious or civic institutions, as well as predatory lending facilities. Understanding these complex relationships would be important for many research and planning disciplines, and reliable parcel-level data like those generated by the CSI, enable this fuller range of analyses. We have shown that it is practical to capture detailed and analytically flexible data that can be used to calculate actual densities or distances of not only particular uses but mixes that might be determinative of health.

Few of the current studies examining the role of the built environment on health issues such as obesity or physical activity have employed direct measures of the built environment.[1,18,24-25] Given that the accuracy of some of the databases used to study environmental correlates has been questioned, our current knowledge about environmental risk or protective factors related to health might be flawed. Employing measures like the CSI can be used to augment studies using existing database or Census-based proxies of environmental risk and protective factors in order to address potential inaccuracies and to provide data on the actual number of mixed and multiple uses per parcel for analysis. Future built environment studies should employ direct observations measures such as the CSI to confirm what we think we know about environmentally-based risk and protective factors, particularly those examining the impact of the built environment on physical activity or obesity risk since this is where much of the research activity has taken place.

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