Evaluating closures of fresh fruit and vegetable vendors during COVID-19: methodology and preliminary results using omnidirectional street view imagery

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Submitted to: JMIR Formative Research
on: August 26, 2020

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Abstract

Background: The COVID-19 pandemic has disrupted different facets of the food retail environment, however its impact on smaller fruit and vegetable (FV) vendors (which are often community-based and may not have the financial infrastructure to withstand changes in supply and demand induced by the COVID-19 pandemic) remains unclear.

Objective: This study documents the methodology used to assess service changes among FV vendors in New York City (NYC) following the COVID-19 pandemic by using Google Street View (GSV), the new Apple Look Around database, and in-person checks.

Methods: Six NYC neighborhoods were selected for analysis in Manhattan and Brooklyn; two socio-economically advantaged neighborhoods (Upper East Side, Park Slope), two socio-economically disadvantaged neighborhoods (East Harlem, Brownsville), and two Chinese ethnic neighborhoods (Chinatown, Sunset Park). For each neighborhood, GSV and Apple Look Around were used to virtually walk down each street and identify FV vendors (stores, storefronts, street vendors, or wholesalers) which were open and active in 2019 imagery data; past FV vendor surveillance (when available) was used to guide these virtual walks. Each identified vendor was then geotagged as a Google Maps pinpoint. Research assistants then conducted socially distanced in-person checks to each site and, using the "notes" feature of Google Maps as a data collection tool, made notes on whether each vendor was open, open with limited services, or closed/absent.

Results: A total of 135 vendors confirmed to be open in 2019 were identified; 80 vendors in the Manhattan neighborhoods (56 in Chinatown, 12 on the Upper East side, and 12 in East Harlem) and 55 vendors in the Brooklyn neighborhoods (48 in Sunset Park, 4 in Park Slope, and 3 in Brownsville). Overall, 44% of vendors were either absent/closed or had limited services following COVID-19.

Conclusions: The triangulated methodology was effective in identifying changes in the FV retail environment and can be employed to assess COVID-19 changes in other contexts. The use of past baseline surveillance to assist GSV-based FV vendor identification was found to be valuable. Apple Look Around was likewise effectively able to provide updated 2019 NYC imagery data when 2019 GSV imagery was not available. The Google Maps "notes" feature was able to provide real-time information to multiple members of the study team; the platform can significantly enhance the efficiency of field work for future studies.

(JMIR Preprints 26/08/2020:23870)

DOI: https://doi.org/10.2196/preprints.23870

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Acknowledgements: This publication is supported by grant numbers U54MD000538 from the National Institutes of Health (NIH) National Institute on Minority Health and Health Disparities, and R01HL141427 from the National Heart, Lung and Blood Institute. The contents of this publication

are solely the responsibility of the authors and do not necessarily represent the official views of the NIH.

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Abstract

Background: The COVID-19 pandemic has significantly disrupted the food retail environment, however its impact on fresh fruit and vegetable (FFV) vendors remains unclear, which are often smaller, more community-centered, and may lack the financial infrastructure to withstand supply/demand changes induced by such crises.

Objective: This study documents the methodology used to assess FFV vendor closures in New York City (NYC) following the COVID-19 pandemic by using Google Street View (GSV), the new Apple Look Around database, and in-person checks.

Methods: Six NYC neighborhoods were selected for analysis in Manhattan and Brooklyn; two socio-economically advantaged neighborhoods (Upper East Side, Park Slope), two socio-economically disadvantaged neighborhoods (East Harlem, Brownsville), and two Chinese ethnic neighborhoods (Chinatown, Sunset Park). For each neighborhood, GSV was used to virtually walk down each street and identify FFV vendors (stores, storefronts, street vendors, or wholesalers) which were open and active in 2019 (i.e., both FFVs and vendor personnel were present at a location). Past FFV vendor surveillance (when available) was used to guide these virtual walks. Each identified vendor was then geotagged as a Google Maps pinpoint which research assistants then physically visited; using the "notes" feature of Google Maps as a data collection tool, notes were made on whether each vendor belonged to one of three categories: 1) open, 2) open with more limited set-ups (e.g., certain sections of the FFV vendor unit that were open and active in 2019 but were missing or closed during in-person-checks), or 3) closed/absent.

Results: Of the 135 open FFV vendors identified in 2019 imagery data, 35% (n=47) were absent/closed and 10% (n=13) were open with more limited set-ups following the COVID-19

pandemic. When comparing boroughs, 35% (n=28) of vendors in Manhattan (n=80) were absent/closed, and 35% (n=19) of vendors in Brooklyn (n=55) were absent/closed. Although GSV was able to provide 2019 street view imagery data for most neighborhoods, Apple Look Around was required for 2019 imagery data for some areas of Park Slope. Past surveillance data helped to identify 3 additional established FFV vendors in Chinatown that had been missed in street view imagery. The Google Maps “notes” feature was employed to rapidly collect observational data by multiple research assistants simultaneously on mobile devices.

Conclusions: The methodology employed was able to identify closures in the FFV retail environment and can be used to assess closures in other contexts. The use of past baseline surveillance to assist FFV vendor identification was valuable in identifying vendors that may have been absent or visually obstructed in the street view imagery data. Data collection using Google Maps likewise has the potential to enhance the efficiency of field work in future studies.

Words: 437/450

Key words: built environment; Google Street View; food retail environment; COVID-19; geographic surveillance

Background

The COVID-19 pandemic has evolved into one of the most significant and socially disruptive health crises in recent history, with growing concern for how food systems at both the global and local levels are being affected by the dramatic economic and social impacts of the pandemic [1]. Given the significance of the retail food environment in fostering and maintaining healthy diets [2] disruptions

to certain components of this environment, such as access to fresh fruits and vegetables (FFV), has the potential to detrimentally impact population health, and has already been identified as an area of concern [3]. Although early observational evidence of Google search frequency data suggest greater search-based interest in fresh foods during the COVID-19 pandemic [4], which supports shopping behavior data showing a significant increase in FFV sales during the early months of the pandemic (although demand is stabilizing) [5]. Moreover, social distancing measures are significantly impacting direct sources of fresh produce, such as farmer's markets [3].

Although national and international supermarket chains, warehouse clubs, and supercenters dominate grocery retail [6], fruits and vegetables are sold in a variety of other food retail environments as well. FFV vendors are often smaller and more community-oriented than other restaurant or retail food outlets, and can include chain or independent grocery stores, greengrocers, storefront stands (or simply "storefronts," i.e. areas in front of stores used to sell FFV), street-carts, and even makeshift platforms focused on the sale of fresh fruits and vegetables [7]. Although fresh produce as opposed processed produce (i.e. canned, dried, or frozen produce which can often be found in other larger food retailers) may not hold substantially higher nutritional value [8], and while fresh produce may also be purchased at these larger food retailers [9], smaller community FFV vendors who may conduct business on the sides of major streets or on storefronts have played an integral role in the food environment in large urban centers such as New York City (NYC) [10], particularly in ethnic enclaves where they represent a significant source of fruits and vegetables [7].

Many FFV vendors (particularly street carts selling FFV) in cities across the United States (US), including NYC, have been forced to close due to the dual concerns of plummeting demand and fear of contracting COVID-19 [11, 12]. Within cities, the importance and presence of FFV vendors varies by neighborhood. In Chinatown Manhattan, FFV vendors are known for their low prices and play a significant role in the food retail environment as a critical food source for socially and economically vulnerable populations (e.g., the elderly [13]) which have been a growing proportion of

Chinatown Manhattan's demographic make-up. Furthermore, these FFV vendors are magnets for tourists and interborough shoppers from diverse cultural backgrounds--not only Asian--who are looking for items that cannot be found elsewhere in the city, or for the same low costs [7].

Unlike larger, well-established grocery store vendors, these FFV vendors (which are relatively smaller and more community-centered) may not have the financial infrastructure to withstand changes in supply and demand induced by the COVID-19 pandemic [14], thus the risk for closure or changes in services may be more significant. Likewise, many FFV vendors in NYC tend to be immigrants [7, 15], often with low English proficiency [7], and thus may not have the same social and economic capital or legal protections to maintain the retail resiliency of other vendors. Therefore, understanding how the pandemic has impacted FFV vendors can provide vital insights into changes in FFV food environments in large urban centers, such as NYC, where these community based FFV vendors are a significant part of the fresh produce environment.

Evaluating the impact of COVID-19 on services provided by FFV vendors fundamentally requires surveillance data both before and after the onset of the pandemic. Given that updated surveillance data of the diverse types of community FFV vendors may not be available (particularly for the more informal, street based FFV vendors), Google Street View (GSV) is a promising platform for data collection in this context. GSV has been employed in a variety of health research contexts [16], including assessing local food environments [17, 18], and is a less resource-intensive, easily accessible source of visual data in comparison to other forms of visual data collection such as those relying upon in-person field work [16]. GSV data is usually collected from cars sent out by Google, which are equipped with cameras with the ability to capture 360-degree views in a particular location. Image data is then geo-tagged and uploaded on Google platforms (such as Google Maps) accessible for public use [19]. Importantly, these GSV images are routinely updated. Large urban centers in high-income countries, e.g., NYC, often have more recent GSV imagery data in comparison to other locations [16], which is likely given that a location's population density

contributes to the frequency of street view imagery updates conducted by Google [19]. For example, in June 2020, NYC GSV imagery data from June and October 2019 could accessed.

In the past, GSV has been employed through cross-sectional or validation-based study designs, thus the use of the platform for longitudinal health research in neighborhood settings is an area in need of more exploration [16]. Likewise, while longitudinal analysis of GSV data has been effective in retrospectively analyzing changes in food retail environments, the use of the platform to analyze more recent changes – by triangulating information from the platform with other means of surveillance – remains underexplored [20].

Therefore, the aim of this study is to document the methodology developed to assess closures in the food retail environment (notably closures of FFV vendors) before and during the COVID-19 pandemic in NYC using triangulated data from GSV, past surveillance (when available), and Google Maps based, socially distanced in-person assessments. Specifically, we document 1) the specific procedures used to conduct both pre-COVID and during-COVID FFV surveillance such that it may be replicated by others in other locations, and 2) the strengths and limitations of this methodology, as well as the challenges faced. Importantly, as opposed to analyzing general net changes in the FFV food retail environment (which has been explored other food retail environments using street view data [20]), a specific focus of this methodology was to analyze closures and other visually observable service impacts on pre-existing vendors directly prior and during disruptive crises such as COVID-19.

Methods

Baseline FFV vendor assessment: Past surveillance data

NYC is divided into five boroughs, which each contain many neighborhoods. The boroughs of Manhattan and Brooklyn were analyzed in this study. Neighborhoods were defined using NYC Neighborhood Tabulation Areas, and further details on their identification have been described

elsewhere [21, 22]; in short, data on socio-economic and health disparities of Manhattan and Brooklyn neighborhoods were used to select one socio-economically advantaged neighborhood (Upper East Side, Park Slope), one socio-economically disadvantaged neighborhood (East Harlem, Brownsville), and one Chinese ethnic neighborhood (Chinatown, Sunset Park) in each borough. An ethnic Chinese neighborhood was selected for analysis in each borough given observational evidence identifying the strong role FFV vendors play in the fruit and vegetable retail environments within Chinese ethnic neighborhoods in NYC [7]. Past surveillance data on the locations and types of FFV vendors in the select 3 neighborhoods in Manhattan (Chinatown, Upper East Side, and East Harlem) and 3 neighborhoods in Brooklyn (Sunset Park, Park Slope, and Brownsville) were first identified in order to establish the FFV vendor landscape from which pre-COVID and during-COVID assessments were to be conducted.

The importance of identifying past surveillance data to guide the pre-COVID FFV vendor identification lay in two points. First, one of the key limitations of GSV data extraction is that visual obstructions in the GSV image may conceal FFV vendors – e.g., in the NYC Chinatown extraction, trucks parked in the street could make sidewalks and some smaller FFV vendors (e.g., makeshift platforms) difficult to view or notice. Therefore, the non-GSV surveillance data allows one to account for these visually obstructed and inconspicuous FFV vendors. Second, some FFV vendors in cities, such as NYC, operate in a temporary capacity, with some also utilizing makeshift physical locations in areas such as parking lots. Therefore, integrating past cross-sectional non-GSV surveillance data with visual data from GSV aids in identifying long-term vendors allows for a more comprehensive, precise evaluation of how COVID-19 has impacted established FFV vendors that operate in a more sustained capacity within the community.

Imbruce (2015) collected in-depth FFV surveillance data in Chinatown, which was used as the baseline FFV assessment for this neighborhood, given the diversity of FFV vendors and specificity of geographic information included in the dataset [7]. Equivalent information was not

available for the other five neighborhoods. However, Fuchs et. al (2014) did collect geographic data on a small percentage of locations of “Green Carts” (mobile street vendors specially permitted to sell exclusively fresh FFV) in East Harlem and Brooklyn [15]. This information therefore used as a guide to identify potential locations of FFV vendors in the pre-COVID assessment of these neighborhoods, using GSV to concretely identify FFV vendor locations. Importantly, given this past surveillance data was quite dated (ranging from 2003 to 2013) and that FFV vendors are likely to have changed between then and 2019, this supplementary surveillance data was largely used to identify any additional *potential* FFV vendors or locations of past clusters of FFV vendors during in-person checks which, if identified during in-person checks, may identify vendors which may have been otherwise missing or visually obstructed in the 2019 street view imagery data. For the Upper East Side, Park Slope, and Sunset Park, for which there were no comprehensive or reliable baseline FFV vendor assessment data sources, GSV was solely relied upon to identify pre-COVID vendors (Table 1).

[INSERT TABLE 1 HERE]

In order to allow for disaggregated analyses, FFV vendors identified in either the baseline or pre-COVID assessments were categorized into four types (store/supermarket, storefront, street vendor/other and wholesale) based on criteria identified by Imbruce (2015) (Table 2) [7]. While some of the terminology for these categorizations has been employed in different ways in past research [23], for the purposes of this study, the definitions provided by Imbruce (2015) (which were based on in-depth field work in NYC Chinatown) were used to defined different FFV vendors.

[INSERT TABLE 2 HERE]

Pre-COVID FFV vendor assessment: GSV extraction

A spreadsheet was created using the datapoints identified from the baseline FFV assessment. For Chinatown, each baseline datapoint was given a unique ID number from this prior surveillance data [7], and any other information provided by the survey (e.g. street location, category of FFV vendor) was included. Given that many FFV vendors (notably street carts) may not have visibly identifying features, the identification of these unique FFV data points was informed by 1) the specific street address where a particular vendor was located, 2) the type of vendor (e.g. if a street cart FFV vendor was stationed in front of a store/storefront FFV vendor at the same street address, these would each get unique ID numbers). GSV was then employed to ascertain whether the FFV vendor corresponding with each unique ID was visible (labeled as "found") from a 2019 GSV image at the approximate location identified from the prior surveillance data [7]. For all other neighborhoods, since reliable past surveillance data was not available to guide the GSV assessment, research assistants virtually walked down each street of the neighborhoods using GSV and catalogued all FFV vendors they identified in a spreadsheet along with the approximate street location, date of GSV image, and any notes relevant to the vendor's services or its location.

From the street view image at the location of the baseline site, a FFV vendor datapoint was labeled as "found" if 1) the physical location of a FFV vendor was able to be clearly identified, based on the description or category of the vendor provided by the prior survey (e.g. cart, storefront, wholesaler), and 2) there was visual evidence to support the vendor being active, such as the presence of fruits and vegetables and/or individuals actively engaging in consumer activity (e.g. exchanging cash or multiple people holding grocery bags near the vicinity). Example of FFV vendors which did not qualify as being "active" included those with signage indicating ongoing construction or renovation, or indication that the vendor had not yet formally opened for business (i.e. "opening soon"). Vendors with signage indicated changed services (e.g. delivery or takeout only) were classified as "active." Vendors exclusively selling items other than fruit and vegetables (e.g.,

clothes or toys) were not included. Any FFV vendor datapoint that did not satisfy these conditions was labeled as "not-found"; furthermore, if there was visual evidence to suggest that there was a temporarily or permanently closed FFV vendor matching the description from the prior survey at the location of the datapoint, then these observations were noted in a separate “notes” column in the extraction datasheet. Likewise, any other anomalies regarding the visual GSV evidence from the “found” or “not found” FFV vendors were noted in this “notes” column. The time stamp of the GSV image (month and year) was also catalogued. A visual depiction of the information gleaned from the GSV scan is displayed in Figure 1.

[INSERT FIGURE 1 HERE]

Although GSV image data across all neighborhoods was largely timestamped with a 2019 date, some streets in Park Slope were observed to only have GSV imagery data from dates prior to 2019. To address this, research assistants collected street imagery data from Apple Look Around, a new geographic imagery system implemented by Apple in 2019-2020 analogous to GSV [24]. Similar to GSV, Apple Look Around relies upon ground surveys conducted by commissioned vehicles to collect geographic imagery data [25]. Select areas of Park Slope without 2019 time-stamped GSV data were supplemented with 2019 time-stamped Apple Look Around imagery to complete the data collection for this neighborhood.

COVID FFV vendor assessment: Google Maps based in-person checks.

Following the 2019 GSV data extraction, an in-person check was conducted for each FFV vendor between June and July of 2020. All FFV vendors, including those that were either “found” or “not found,” received in-person checks to ensure vendors that may not have been found due to the aforementioned limitations of GSV imagery were not excluded. A protocol for rapid in-person

assessments was designed to specifically incorporate principles of social distancing and minimize outside exposure for research staff. These principles were achieved through two key components of the protocol. First, to minimize the time needed to locate the locations of each FFV vendor and enhance the speed of data collection, several functions in Google Maps were utilized. Specifically, the “Your Places” feature was used to create lists containing the pinpoint locations of each FFV vendor in a shared Google Maps account. The “notes” feature of each pinpoint was then used to record the unique vendor ID, and other information from the pre-COVID assessment stage relevant to the in-person checks (such as name and category of vendor identified from GSV or baseline surveillance). From the spatial data of the FFV vendor pinpoints, an in-person check route was designed to optimize the amount of walking or driving required. During the in-person checks, research staff accessed Google Maps on their mobile phones using the shared account with the FFV vendor lists and pinpoints. Second, measures were taken to also enhance social distancing for research stuff, which (along with the standard government-mandated use of face masks at the time of the visit) included conducting in-person checks by car when possible (largely to identify street cart or storefront FFV vendors which could be identified in a car). Finally, data collection was conducted largely during the afternoon, on different days of the week, and not during periods of inclement weather to minimize the potential of conducting data collection during routine or temporary FFV vendor closures.

When a pinpoint was reached, research staff used the “notes” feature, which contained the pre-COVID information, to catalogue the during-COVID assessment data, including: 1) if the vendor was found, and if so, whether the vendor was observed to be open, open with more limited set-ups, or closed, 2) the date the in-person check was conducted, 3) any notes about the vendor or its services. Given that physical location of vendors may have slightly changed (notably street cart FFV vendors), to help in the identification of a particular vendor, research assistants examined all street addresses in close proximity the noted location (e.g. examining a few street numbers to the left and

right of the location) as well as information from the pre-COVID street view imagery indicating the types of produce being sold at the location. “Open with more limited set-ups” was noted when vendors appeared to have slightly changed or offered fewer services than what was observed during the GSV pre-COVID extraction (e.g. FFV stores closing the outdoor portions of their services, or certain sections of street carts closed or selling fewer quantities or variety of produce). Examples of notes made during in-person assessments included if a vendor was likely replaced by a new store, or if the vendor was sharing services or affiliating with another vendor. Figure 2 displays an example of the Google Map pinpoints and “notes” feature interface used for the in-person data collection.

[INSERT FIGURE 2 HERE]

Importantly, during data collection, research assistants may have also encountered FFV vendors outside of those with Google Maps pinpoints based on the baseline and street view imagery data. Given the focus of this methodology to evaluate closures and other visually observable service impacts on FFV vendors, such vendors lacked the pre-COVID 2019 street view or baseline surveillance data to be eligible to be included in the *longitudinal* assessment of FFV closures, and thus systematic data collection was these vendors was not conducted. Nevertheless, throughout data collection, research assistants reported these additional vendors to the study team.

Results

The initial GSV extraction (partially informed by baseline data in the case of Chinatown) identified 80 vendors in the three Manhattan neighborhoods; 56 in Chinatown, 12 on the Upper East side, and 12 in East Harlem. A total of 55 vendors were also identified in the three Brooklyn neighborhoods; 48 in Sunset Park, 4 in Park Slope, and 3 in Brownsville. Although only 53 vendors were identified using GSV in Chinatown, during in-person checks, 3 additional vendors were identified that had

been noted in the baseline surveillance data but not found using GSV, increasing the total vendor sample of Chinatown to 56. A summary of the preliminary extraction data and COVID closure data is presented in Table 3. An example of the data visualization methods used to highlight COVID closures is displayed in Figure 3. Overall, 60 out of the 135 vendors (44%) identified in all 6 neighborhoods were either absent/closed or had more limited set-ups following the COVID-19 pandemic.

[INSERT TABLE 3 HERE].

[INSERT FIGURE 3 HERE].

Discussion

The integrated GSV-centered longitudinal assessment of FFV vendors was able to identify significant closures among FFV vendors during the COVID-19 pandemic by comparing evidence from shortly before the pandemic in 2019 and evidence during the pandemic. While causality behind the identified closures cannot all be directly be attributed to the COVID-19 pandemic itself using this preliminary surveillance evidence, this approach helped to highlight the extent of pre-pandemic to during-pandemic closures within a facet of the food retail environment with limited formal, consistent surveillance which nonetheless play an integral role in underserved ethnic minority communities, such as those in NYC Chinatown [7]. Likewise, GSV data could be transferred efficiently into Google Maps pinpoints to facilitate time- and resource-efficient in-person checks. To the best of our knowledge, the use of the “notes” feature of Google Maps has not been explicitly employed as a data collection tool in past health research. The use of Google Maps was able to provide real-time information to multiple members of the study team on which sites and been catalogued, evidence that the platform can significantly enhanced the efficiency of field work for

future studies, particularly in resource- and time-scarce contexts such as the COVID-19 pandemic.

Importantly, use of past baseline surveillance (when available) to assist in FFV vendor identification during the pre-COVID assessment was found to be valuable; the identification of 3 vendors in Chinatown that were not found in GSV but found in both the baseline assessment and in-person supports preliminary concerns that visually obstructed vendors may be missed in GSV imagery. Further utilization of GSV should also consider supplementing assessments with other data sources, particularly when assessing objects that may be susceptible to being missed or obscured in GSV imagery [16]. These findings directly support evidence from prior GSV research, which similarly identified image quality and visual obstructions as areas of concern [16]. However, unlike many past studies, the date of capture for the analyzed GSV imagery was consistently recent (almost always sometime within 2019) [16]; this was likely due to NYC being the study setting of the project, a large populated area likely to be frequented by Google-commissioned cars for GSV surveillance. Given that large, urban environments have been particularly affected by the COVID-19 pandemic [26], GSV may be particularly useful in conducting pre-COVID vs. during-COVID (or post-COVID) assessments in these environments.

Likewise, given the significant disparities in food purchasing behavior – including quantity and quality food as well as frequency and sources of food access - across various minority populations in the US, the importance of this methodology also lies in its ability to survey aspects of the food retail environment that may be critical to underserved minorities, such as Asian Americans [7]. While conducting pre-COVID/during-COVID closure assessments for storefront food vendors, e.g., restaurants or grocery stores, can utilize a variety of sources of information, such the Internet (Yelp, Google, social media, etc.) or publicly available phone numbers [21], FFV vendors are relatively disconnected from public information databases as they cater to localized populations and may operate less formally than other food retail outlets. Given these FFV vendors both serve and are often managed by vulnerable minority populations [7, 15], understanding the significance of this

methodology with respect to health equity concerns in food retail environment surveillance is paramount.

Nonetheless, there were a number of limitations faced throughout the study. First, it's important to acknowledge that some vendors may have been closed for the day at the time of GSV image capture or in-person checks, which may have led to an overestimation of COVID closures. These potential routine or temporary closures have particularly impacted the assessment of street vendors (as opposed to stores or storefronts, which may have more established operating hours or more staff to assist in consistently operating). These concerns were mitigated in two ways: 1) baseline data helped to corroborate any vendors that might have been missed in GSV extraction, and 2) in-person checks were conducted at times of the day when most food retail vendors (including FFV vendors) are open (notably afternoon, early afternoon).

Moreover, while steps were taken to assist in-person checks of FFV vendors that may have slightly adjusted geographic location, some vendors that may have moved locations to an entirely different street of completely changed their services between 2019 and 2020. Likewise, while the sample of vendors included in the pre-COVID assessment was maximized by using recent (largely June and October 2019) imagery data along with supplemental past surveillance to identify established FFV vendors which may have been obstructed or missed in street view imagery but were present in in-person checks, some vendors that been missed in these data sources or those had opened later in 2019 but still prior to COVID-19's impact in the US were unable to be examined. However, while systematic data collection of additional vendors identified during in-person checks was not conducted, research assistants did not report more than a few additional FFV vendors in each neighborhood outside of the pre-COVID sample in part due to the aforementioned efforts as well as the short time frame between the pre-COVID and during-COVID data assessments. Nonetheless, while examining net-changes in the food retail environment was not a focus of this particular methodology, the incorporation of systematic analysis of new vendor openings after disruptive crises

such as COVID-19 is another area worthy of exploration (including across different types of food retail outlets).

Finally, it is likely that some FFV vendors may have closed for some time early on in the pandemic but may have recently re-opened. Alternatively, vendors may have opened shortly after the particular day in-person checks were conducted, but still within the June-July 2020 endpoint timeframe. This is indeed a limitation of the approach – in order to provide the most accurate, cross-sectional COVID surveillance, data collection must occur within a short period of time. In the current case, due to the novelty of the methodology, many of its components were being developed and tested by study authors throughout each stage, thus limiting the speed of the in-person checks. Likewise, due to the COVID-19 pandemic, caution also had to be taken in timing the in-person checks to minimize outdoor exposure for research staff. However, we intend on doing targeted follow-up assessments in subsequent months.

Indeed, the methodology described in the study has significant implications for research aimed at longitudinally assessing recent closures in the food retail environment (particularly among FFV vendors or other retailers with limited public surveillance data) during time- or resource-sensitive timeframes, including disruptive health crises such as COVID-19. For example, the impact of COVID-19 on the FFV retail environment has been felt by other communities across the US; FFV vendors in Los Angeles have witnessed a dramatic drop in sales [27], which may be catalyzing vendor closures. Moreover, to address the sales and logistical disruption faced by many FFV vendors, new online-based delivery services for FFV vendors have been explored in limited settings [28]; future research may explore surveillance of different strategies being explored to adapt services and prevent closures among FFV vendors. Likewise, it's important to contextualize the potential economic or food access impacts related to FFV closures identified in this methodology with broader health or social impacts of the COVID-19 pandemic; complementing this methodology with other mixed-methods approaches to assess economic, health, and social impacts of the COVID-19

pandemic is warranted. Finally, to the best of our knowledge, this study was the first to utilize the new Apple Look Around geographic data system for health research. The platform was observed to be efficient and user-friendly in identifying FFV vendors in Park Slope in a manner similar to the use of GSV; however, since the platform was not utilized in the other examined neighborhoods, further research is needed to assess its effectiveness for health research both in NYC and in other settings. With these preliminary insights from Park Slope, future in-depth analysis comparing the utility of Apple Look Around with GSV and other means of geographic surveillance is warranted, particularly with respect to parameters such as image quality, geographic scope of the data, timeliness of surveillance updates, and other features of the different platform that can assistant in health research.

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Table 1: Data sources used to assess COVID closures of FFV vendors

Neighborhood	Baseline Data	Pre-COVID Data	During-COVID Data
Chinatown	2003-2005 (Imbruce, 2015)	June-Oct 2019 (GSV)	June-July 2020 (In-person)
Upper East Side	None	June-Oct 2019 (GSV)	June-July 2020 (In-person)
East Harlem	2013 (Fuchs et. al 2014)*	June-Oct 2019 (GSV)	June-July 2020 (In-person)
Sunset Park	None	June-Oct 2019 (GSV)	June-July 2020 (In-person)
Park Slope	None	June-Oct 2019 (GSV)^	June-July 2020 (In-person)
Brownsville	2013 (Fuchs et. al 2014)*	June-Oct 2019 (GSV)	June-July 2020 (In-person)

***** Since geographic surveillance data only captured 45/121 and 19/132 of the Green Carts given permits in Manhattan and Brooklyn respectively, and specific location data was not available, this data source was only used to provide general understanding of potential prior locations.

^ Some streets did not have GSV data from 2019, and these areas was supplemented with street-view surveillance from Apple Look Around

Table 2: Types of FFV vendors analyzed, adapted from Imbruce (2015)

Type	Description
Store / Supermarket	Both sidewalk in front of store and inside of the store are used for primarily selling produce (operated by same owner)
Storefront	Only sidewalk in front of a store is used to sell produce.
Street vendor / Other	Produce sold in areas of high foot traffic in spaces near streets, sometimes by itinerant vendors. Also included other types of FFV vendors (e.g. outdoor markets, makeshift stores)
Wholesale	Produce is bought from farms or other produce brokers in high volume and is sold to retail vendors, restaurants, or individuals by the box.

Figure 1: Data extracted from GSV to support fruit and vegetable (FFV) vendor presence

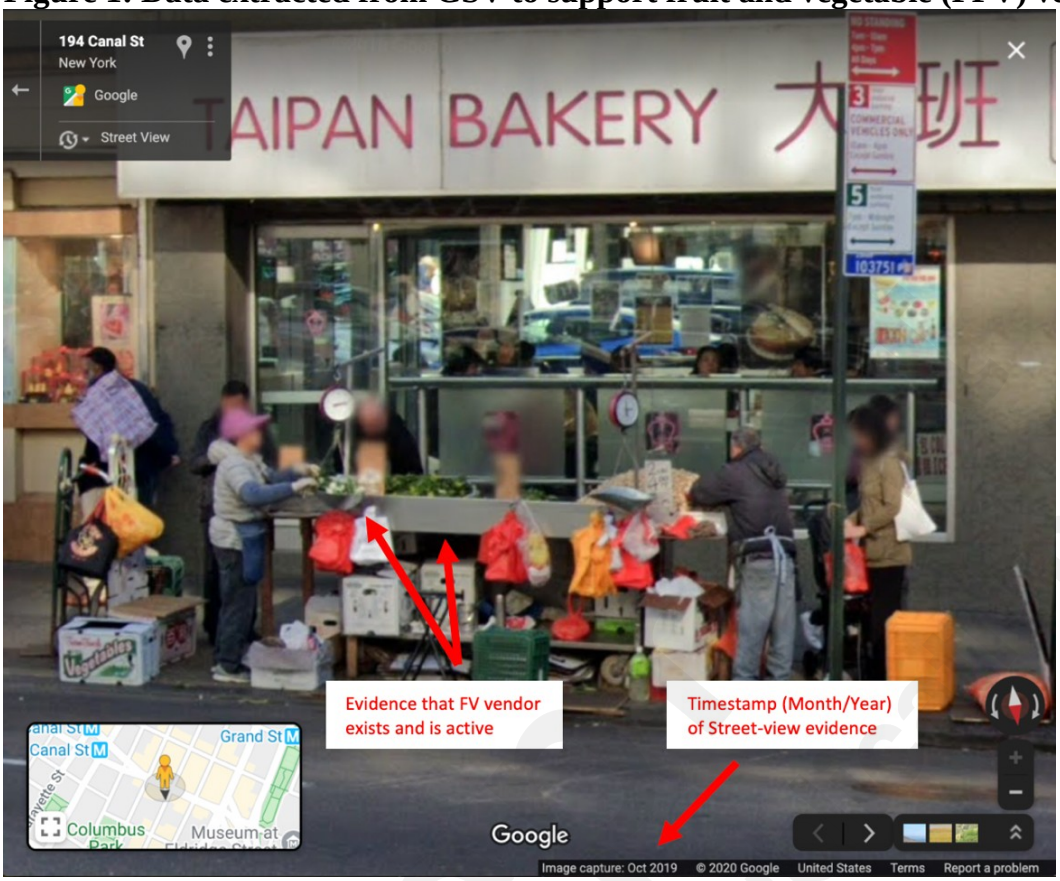

Figure 2: Example of Google Map pins and notes pane used for in-person checks (Chinatown)

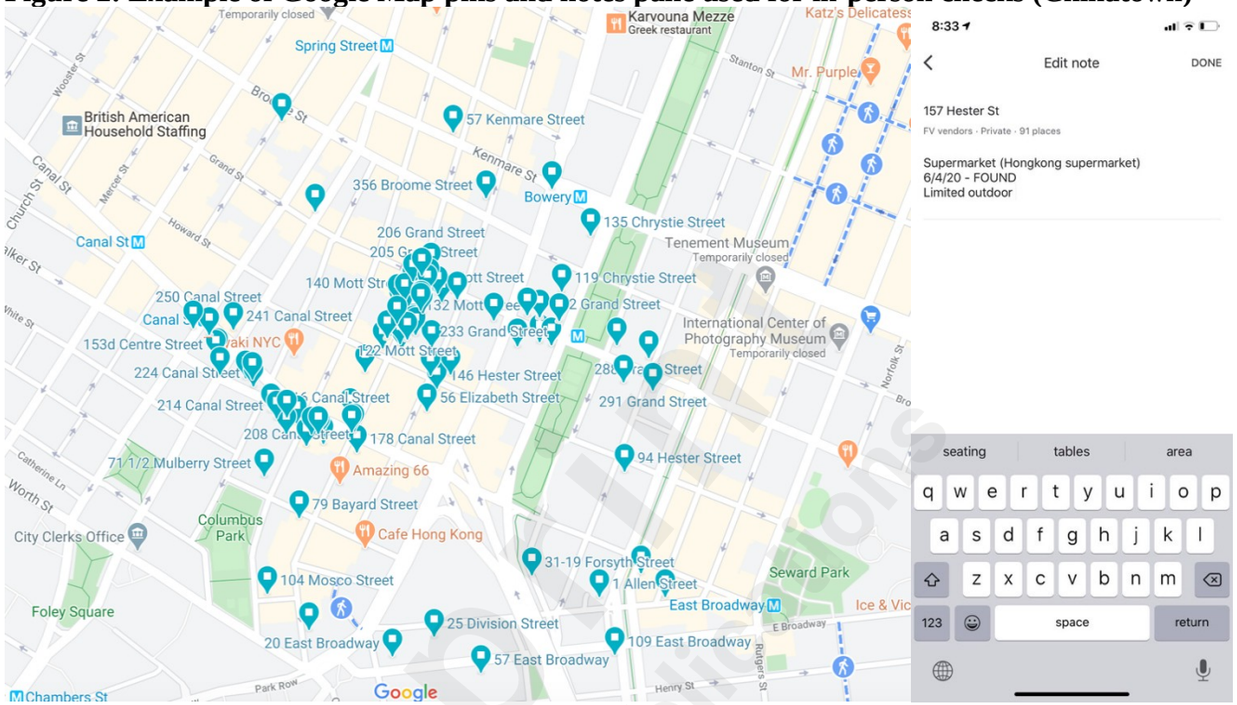

Figure 3: Example of consolidated visual output using data collected from pre-COVID/during-COVID assessments (Chinatown)

Table 3: Preliminary findings on closures of FFV vendors in select Manhattan (NYC) neighborhoods during COVID-19 pandemic using GSV analysis.

Neighborhood	No change	%	Covid – closure	%	Covid – more limited stet-ups	%
Manhattan						
C. Town (56^)	27	48.2%	24	42.9%	5	8.9%
U.E. Side (12)	5	41.7%	0	0.0%	7	58.3%
E. Harlem (12)	7	58.3%	4	33.3%	1	8.3%
Brooklyn						
Sunset P. (48)	30	62.5%	18	37.5%	0	0.0%
P. Slope (4)	3	75.0%	1	33.3%	0	0.0%
Brownsville (3)	3	100.0%	0	0.0%	0	0.0%

^ Includes vendors found in the 2019 GSV check (53) and additional vendors only found during in-person checks but were identified in other baseline surveillance (3).