



RESEARCH ARTICLE

Disposing of single use: Evaluating the effectiveness of Berkeley's anti-single use disposable foodware ordinance

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Single use disposable (SUD) foodware is an increasingly large waste problem in the United States. One strategy to combat this rising problem is through targeted policy mechanisms. In recent years, many local and state jurisdictions have implemented anti-SUD foodware policies, aimed at banning or charging extra for the specific material and/or foodware types. In 2019, the City of Berkeley, California, passed a comprehensive anti-SUD foodware Ordinance, featuring numerous policy mechanisms to reduce SUD foodware, to foster more sustainable practices among food vendors, and be a model for other jurisdictions. Over the 4 years (2019–2022), we collected observational survey data based on the policy's mechanisms to assess prepared food vendors' compliance with the Ordinance and thus its effectiveness. The COVID-19 lockdown slowed adoption and implementation of the Ordinance and our data reflect this. In 2020—the second year of data collection—compliance decreased for 5 of the 8 policy mechanisms, rebounding in 3 of them 2 years later. This article ends with recommendations for actions the City can take to increase vendor compliance with, and thus effectiveness of, the policy. This study also contributes to current research discussions on waste, plastics and sustainability, and provides valuable insight into policy implementation processes on the ground.

Keywords: Single use foodware, Waste, Local policy, Prepared food vendors, Sustainability transition

1. Introduction

In the United States, single use disposable (SUD) foodware (e.g., plates, cutlery, bags, napkins, cups, straws) make up roughly 30% of all waste produced (U.S. Environmental Protection Agency, 2015). In urban settings, SUD foodware comprise 67% of the litter (Clean Water Action, 2024). The United States is consuming SUDs at unprecedented rates (Jambeck et al., 2015) and it is estimated that 85% of the plastic SUDs ever created in the world, or 66,680 million metric tons, was still in existence as of 2017 (Geyer et al., 2017).

To combat this proliferating waste, jurisdictions across the world have rapidly enacted anti-SUD foodware policies (Upstream, 2022; Heiges, 2023). In the United States, this policy movement began by reducing the use of consumer-facing plastic SUDs, item by item: plastic bags (Clapp and Swanston, 2009), plastic water bottles (Lee, 2010), and plastic straws (Schnurr et al., 2018). Eventually, proposals to create comprehensive policies to reduce all plastic SUD foodware emerged

as potentially more effective solutions (Shipton and Dauvergne, 2022).¹ In principle, a policy-based sustainability transition to a SUD foodware-free system focuses on reducing the use of *all* SUD foodware items of *any* material type, not just plastic. The policies designed to effect such change are nascent and their effectiveness is uncertain, especially as very few peer-reviewed studies have appraised their use (Diana et al., 2022). This uncertain effectiveness, however, is not preventing jurisdictions from adopting such mechanisms, particularly at the city level. A leading example is the City of Berkeley in California, which in January 2019 unanimously approved the *Single Use Foodware and Litter Reduction Ordinance* (henceforth the Ordinance).

In this study, we assess Berkeley's novel "model" ordinance (a multi-mechanism policy that other jurisdictions can adopt) through a longitudinal, mixed methods analysis over 4 years. Berkeley is historically a bellwether when it comes to waste reduction efforts, including as one of the originators of curbside recycling in 1973, banning polystyrene in 1990, and adopting one of the strictest bans on SUD plastic bags, including in 2023, a requirement that

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1. While foodware is not the only plastic SUD category, it is one of the most prolific and visible compared to other plastic SUD categories (e.g., medical devices and tools, fishing gear, and cigarette butts) therefore the one most often addressed.

“pre-checkout” (e.g., produce) bags be made from recycled content paper or compostable material, or have a 10-cent fee if they are plastic in 2023 (Skinner, 1988; Harrison and Hahn, 2022; Ecology Center, n.d.). The Ordinance has been internationally touted as a model ordinance for other jurisdictions to adopt (Li, 2019), some jurisdictions have already adopted many of its components (Upstream, 2022), and many others have consulted the Ecology Center directly. It is therefore important to assess what occurs in Berkeley, knowing that while the city’s conditions are particular, policy actions can be replicated elsewhere. Additionally, this study provides insight into SUD foodware conditions before, during, and immediately after COVID-19 lockdowns. It examines the COVID-19 lockdown implications for SUD and reusable foodware.

Successful sustainability transitions rely on effective policy and policy mechanisms (Kivimaa and Kern, 2016; Köhler et al., 2019). This is especially true for policies that focus on highly complex transition challenges that do not have a single or quick solution, involve numerous stakeholders, span multiple disciplines, encompass large geographical scales, and take years to initiate and implement. Policies can uniquely bridge the actors, institutions, infrastructure, and technologies, at scale, to initiate, guide, and sustain interdisciplinary collaboration within those entities to foster a sustainability transition. That has been demonstrated with policies such as extended producer responsibility to generate more sustainable governance and management of hard-to-recycle materials like paint, mattresses, and needles/sharps (Cai and Choi, 2019). Facing such complexity, policymaking is not the only pathway, but it is a necessary one (Heiges, 2023). To better understand the role and contributions of policy during a sustainability transition, policy priorities, stakeholder engagement, and mechanisms need to be identified (Porter and Ashcraft, 2020; Rosenbloom et al., 2020).

To this end, the Ecology Center, a nonprofit in Berkeley, California, which operates the city’s recycling and composting (and a partner in this study), is a founding member of the Alliance for Mission-Based Recycling, and runs a zero waste store, has developed a “Disposable Free Berkeley” toolkit to identify some of those components as they pertain to how the Ordinance was developed: who the stakeholders were, what the community input process was like, what was anticipated and unanticipated push-back, and how to create a policy that was unanimously passed by City Council (Ecology Center, 2023).

In this article, we build on this work and analyze the Berkeley Ordinance as an experiment in using policy to help generate a transition to non-SUD foodware. We also evaluate this catalytic policy’s effectiveness in achieving its objectives so far, especially in the face of significant challenges. To do this, we assess the Ordinance against its policy mix (the breath of mechanisms leveraged to create a multipronged policy strategy), policy intensity (the structuring and embeddedness of the policy), and the technology specificity (how conducive the policy is to developing niche innovations). A crucial, often neglected dimension of transition policy is the economic or financial impacts of undergoing a transition (Gibbs and O’Neill, 2016;

Ryszawska, 2016), which can be highly contentious, as was the case in Berkeley for many prepared food vendors (e.g., restaurants, cafes, grocery stores). We thus pay attention to equitable financial structures, the balance of policy mechanisms, and the types of niche innovations to foster. It is also the first publication of a validated quantitative observational survey and methodology, thus providing a standardized data collection and analysis process for anti-SUD foodware policy evaluation in other jurisdictions. We hope that helps further the field for such necessary evaluative tactics and thus anti-SUD foodware policy adoption and embeddedness. In general terms, this study also contributes to current research discussions on waste, plastics and sustainability, and provides valuable insight into policy implementation processes on the ground.

2. Case study and theory

In this section, we lay out the Ordinance’s objectives, phases and policy mechanisms, and describe the theories for analysis—policy mix, policy intensity, and technology specificity—which are the basis for our research questions regarding the Ordinance’s effectiveness.

Implementation of the Ordinance was divided into 3 phases to progressively decrease SUD foodware consumption, landfill disposal, and litter in the city.² To ease the transition to compliance, each phase was set for enactment, then enforcement 1 year later. The 3 phases were as follows:

Phase 1, enacted March 2019: Immediately upon the passing of the Ordinance, all City-owned facilities and City-hosted events must only provide compostable foodware certified by the Biodegradable Products Institute. All prepared food vendors (henceforth “vendors”) that have a bussing station for customers to dispose of their waste must have all 3 color-coded receptacles (compost, recycling, landfill) available and with signage. Finally, all SUD foodware accessories (e.g., cutlery, straws) must be provided by request only or at a self-serve station.

Phase 2, enacted January 2020: If vendors provide SUD foodware, it must be certified compostable, and all SUD cups must have a \$0.25 charge on them that is clearly marked presale (e.g., on menus) and postsale (e.g., receipts).

Phase 3, originally intended to be enacted July 2020: All vendor meals and beverages consumed on-site must be served in reusable foodware.

A few additional components include food vendors being required to remove the SUD cup charge if a customer brings their own cup, or if they have a payment card or voucher issued by the California Special Supplemental Food Program for Women, Infants, and Children (WIC) or an electronic benefit transfer (EBT) card. All food vendors must have a supply of SUD plastic straws behind the

2. For a detailed history of the Ordinance, see the aforementioned toolkit developed by the Ecology Center, titled “Disposable Free Berkeley” (Ecology Center, 2023).

Table 1. Policy mix categories and mechanisms for a sustainability transition

Policy Mix Category	Policy Mix Mechanism
Creative	
C1	Knowledge creation, development, and diffusion
C2	Establishing market niches/market formation
C3	Price-performance improvements
C4	Entrepreneurial experimentation
C5	Resource mobilization
C6	Support from powerful groups/legitimation
C7	Influence on the direction of search
Destructive	
D1	Control policies
D2	Significant changes in regime rules
D3	Reduced support for dominant regime technologies
D4	Changes in social networks, replacement of key actors

According to Kivimaa and Kern (2016), there are 11 policy mechanisms, bucketed into 2 categories—creative and destructive—that, collectively, create a holistic “policy mix” for a more effective policy-based sustainability transition.

counter so if a customer requests one for any reason, including having a disability, they may receive one. Food vendors can apply for hardship waivers if compliance is financially unviable (City of Berkeley, 2019b). Additionally, the City Manager was charged with, among other things, providing a list of acceptable SUD foodware materials and items, launching a reusable food container pilot, and re-evaluating the Ordinance within 3 years (City of Berkeley, 2019a).

The objective of the Ordinance is to reduce the amount of SUD foodware that is landfilled or improperly disposed of (e.g., littering) in Berkeley, California.³ Compliance with an environmental policy is a first step in assessing the policy’s effectiveness as it elucidates the strengths and weaknesses of the policy in terms of shaping behavioral change on the part of targeted actors (Wilson et al., 2012). According to scholars of sustainability transition policy (STP), if there is no compliance with the policy, then it is likely that it had an unsuitable policy mechanism(s) (Kivimaa and Kern, 2016), it was not structured well (Schaffrin et al., 2015), it focused on the wrong solution (Schmidt and Sewerin, 2019), or is not enforced.

Utilizing this STP framework, the first factor determining policy effectiveness is the suitability of the *policy mix*. Typically, anti-SUD foodware policy mechanisms aim to curb demand for SUD foodware items (“destructive” or deterrent policies such as bans, taxes, and fees) but do not necessarily promote the advancement of alternative materials and systems (“creative” or constructive policies

such as grants) (Kivimaa and Kern, 2016; Heiges, 2023).⁴ Kivimaa and Kern (2016) identify 11 such mechanisms, as shown in **Table 1**. In different combinations, the 4 destructive policies and 7 creative policies make up the policy mix. Having greater coverage across the policy categories is thought to create a more holistic strategy and thus better support a more effective and resilient sustainability transition (Kivimaa and Kern, 2016; Köhler et al., 2019). The Ordinance has 5 policy mechanisms, making it unusual among anti-SUD foodware policies. However, as we demonstrate, it overrepresents destructive versus creative policy mechanisms, arguably to its detriment.

Second, an entire policy, even if it is composed of different mechanisms, can be evaluated on its effectiveness by how it is structured, which is known in STP as *policy intensity*. The theory is that the more structured the policy, the higher the likelihood it will result in the desired policy output (Schaffrin et al., 2015). Schaffrin et al. (2015) identify 6 measures of policy intensity that determine the level of structural strength: objective, scope, integration, budget, implementation, and monitoring. The objective is the purpose of the policy and the mechanism chosen, scope is the distribution of resources and burden, and integration is the degree to which the new policy conflicts with existing policy and political action. The budget is the amount of funds to support the different components of the policy and where or how they are sourced. Finally, implementation is who and how the policy is put into effect, and monitoring is the evaluation of the policy. Each measure can be coded, resulting in a quantitative and thus

3. Litter, while a component of the Ordinance’s title and objective, is not directly linked to one of the policy mechanisms (e.g., there is no additional fine for littering or reward for reduction in litter), so in this study, we do not assess the Ordinance’s effectiveness in reducing litter.

4. Destructive policies are akin to “sticks” to dissuade behavior, while creative policies are akin to “carrots” to reward/incentivize positive behavior.

comparable score. A higher score equates to a more structured policy. The Ordinance has a clear objective, scope, and integration. However, to date it arguably has fallen short on budget, implementation, and monitoring.

The third factor determining effectiveness of an STP is technology specificity. Developed in the renewable energy space, the measure originally focused on the technology(ies) established by a given policy. Here, we translate the concept to other niche innovations like business models, and therefore we instead use the term *niche innovation specificity*. Theory suggests that there must be sufficient policy to establish a certain niche innovation, and that more than one niche innovation should be established to increase the effectiveness of an STP (Schmidt and Sewerin, 2019; Rosenbloom et al., 2020). The Ordinance focuses on fostering 3 niche innovations: reusable foodware, alternative materials, and waste reduction. However, the Ordinance is too reliant on reusable foodware as a niche innovation to reduce SUD foodware that is landfilled or improperly disposed of.

We thus hypothesize that the Ordinance, therefore, may be overweighted on destructive policies, have insufficient policy intensity, and do not sufficiently foster niche innovations, such as reusable foodware systems. We designed a study to analyze this argument because of the importance and potential influence of this policy. It is worth noting that, outside of a nonbinding referral to the City Manager from Councilmembers, the city did not plan efforts in advance to evaluate the Ordinance's effectiveness. That trend of policy adoption pre-validation has precedence. In California, jurisdictions commonly adopted SUD plastic bag bans not because they were necessarily more effective than other mechanisms, but because other jurisdictions had already adopted them (Wagner, 2017). Thus, this study fills a crucial gap by generating evidence of effectiveness to inform any alterations to the Ordinance and subsequent adoption by other jurisdictions.

3. Research questions and methodology

Because the Ordinance fundamentally depends on food vendors across the City of Berkeley for compliance, we focused on this actor group to understand how suitable the policy's mechanisms are, how well it was structured, and if it focuses on the right solutions. We therefore did not investigate consumer experiences and practices because they were not the actor charged with complying with the Ordinance's mechanisms. To guide a longitudinal study of vendor behavior during the first 4 years after the Ordinance's adoption, we developed 3 research questions:

1. What were the different rates of compliance with the Ordinance's 5 policy mechanisms (reusable foodware, bussing stations with all 3 waste receptacles and proper signage, a 25-cent charge for all SUD foodware, and all foodware accessories only provided by request or at a self-serve station)?
2. How did the policy's intensity influence compliance rate?
3. Was there progress in greater adoption of the 3 niche innovations (reusable foodware, alternative materials, and waste reduction) over the 4 years?

To address our 3 research questions, we developed a quantitative observational survey and conducted qualitative interviews. Survey questions focused on vendors' compliance with the policy mechanisms in the 3 phases of the Ordinance rollout. Six subject matter experts from different disciplines and perspectives (e.g., resource economics, public health, political science) reviewed the survey questions and structure before it was field tested. A member of this research team conducted the field test at 2 vendor sites outside of the sample group, then revised the survey for clarity, ease of data collection, and to ensure the data desired were the data captured. Annually, 10–30 trained data collectors filled out the survey by conducting observation of vendor premises, in order to not influence the vendors' practices.

The sample group of vendor sites surveyed was randomly selected. In early 2019, we received a list of all registered vendors, totaling 913 in all, from the City of Berkeley's Department of Economic Development. We culled that list to include only vendors required to abide by the Ordinance. Next, we created 7 strata of food vendors to acknowledge potential compliance nuances by vendor type: bakeries, farmers markets, food products stores (grocery store, convenience store), food service establishments (café, restaurant), food trucks, gas stations, and theaters. Then we randomly selected 150 vendors to achieve a 95% confidence interval within each of those strata. This approach provides internal and external validity for the generalization of the results across the city, as well as reduces biases in the results.

We collected these survey data for 4 consecutive years (2019–2022), during the same 1-month (November–December) time frame each year. We selected this time frame because it was the earliest, we could design, build, and conduct a survey after the Ordinance was passed and before the first phase went into effect. Also, it did not overlap with the Christmas to New Year's holidays, which historically have different consumption patterns and vendor operations. For each round of data collection, we had between 15 and 40 data collectors. The data collectors were undergraduates from the University of California at Berkeley, Berkeley community members, and members of the research team. Each data collector participated in a training prior to entering the field. For their participation, they received course credit and/or a small stipend per vendor site visited to cover their survey cost. The survey cost was the purchase of a beverage item at the vendor site.

Data collectors visited the vendor site in the morning/afternoon, afternoon/evening, or any time of the day based on the vendor's hours of operation. We intentionally did not dictate the specific hour of day or day of the week to visit to eliminate any temporal confounding variables. Once at a vendor site, data collectors ordered a beverage to gain insight into the SUD foodware operations as they related to the Ordinance, such as what foodware accessories are provided automatically with an order and if the SUD cup charge is itemized on the receipt. They also captured related items, such as if the employee asked if the

beverage is “for here or takeout”⁵ and if there are any discounts on customers bringing their own reusable cup. The entire survey is available in Supplemental Material, Table S1.

Originally, the survey methodology included an observational tallying of the number of beverages purchased at a given vendor site during a 30-min period. That component of the survey was removed after the baseline collection round in 2019 due to COVID-19 restrictions for on-site food and beverage consumption at vendor sites.⁶ Each vendor site was surveyed by one data collector each year. Vendor sites were not included in subsequent years if they closed or if their site location changed. If the vendor site reopened, then it was surveyed the following year(s). We did not survey a vendor site if the site changed because there are too many confounding variables associated with such a move (e.g., at the new site, the vendor does or does not have a dishwasher, there is or is no space for waste receptacles, and its patrons are more or less vocal on sustainability matters).

We did not include data collection regarding food and beverage orders obtained through delivery, either directly from a vendor or from a third party (e.g., Doordash). We omitted this type of food purchasing because our research focus was on vendor-based compliance and the incorporation of a third-party delivery service made it too difficult to collect uncompromised data for any meaningful insight.

We interviewed 4 people who were directly associated with the Berkeley Ordinance or a similar ordinance in a different California jurisdiction.⁷ These expert interviews focused on the similarities and differences between the policies, including the successes and hurdles in their implementation.⁸ They were conducted between

5. An employee asking if the beverage is “for here or takeout” is not directly in the Ordinance but is related because it indicates if the beverage should be served in a SUD or reusable cup. Employees are supposed to ask regardless because in most cases, food and beverages meant to be consumed on-site are taxable, while not all food and beverages that are takeout are taxable (California Department of Tax and Fee Administration, 2022).

6. On March 4, 2020, California Governor Gavin Newsom declared a state of emergency for COVID-19 (Office of Governor Gavin Newsom, 2020a). On March 16, 2020, Alameda County, which Berkeley is in, issued a shelter-in-place order for all nonessential activities (Lyons, 2020). Then on March 19, 2020, Governor Newsom issued a shelter-in-place order for the entire state (Office of Governor Gavin Newsom, 2020b).

7. We define “directly associated with” as a person who is a city or county staff member, who is on a city or county commission, or who is part of an organization that supported the development of and/or implementation of the policy. We define “the Ordinance or a similar ordinance in a different California jurisdiction” as either the policy of focus for this study or a policy that is similar in its intent, scope, and/or mechanisms” but is not in Berkeley, California.

8. We also interviewed 3 vendors (managers) of 2 local and 1 global food service establishments. We did not include their data due to indecisive data based on the sample size but would suggest expanding this part of the study in future research. The sample size was smaller than intended because of the financial and time constraints COVID-19 had on such establishments.

November 2022 and February 2023. Each interview lasted between 30 and 60 min, and each interviewee was aware of the quantitative observational survey portion of the study. These interviews help inform our interpretation of the survey data but do not provide insight into causal pathways.

For analysis, the quantitative data were analyzed on Excel through descriptive statistics, VLOOKUPS, pivot tables, and trend analyses. For the qualitative data, all interviews were transcribed and coded based on the content’s relation to the Ordinance.

4. Results

The results for this analysis pertain only to vendors surveyed in Berkeley. We do not include results on the control group here because it is outside of the scope for this study. The number of vendor sites surveyed over the 4 years was 157 in 2019, 125 in 2020, 124 in 2021, and 124 in 2022. During that time, on average, food service establishments represented 81% of registered vendors, food product stores counted for 8%, and the remaining 11% included bakeries, farmers’ markets, food trucks, gas stations, and theaters. We note here, again, the impacts of COVID-19 lockdowns on our data-gathering efforts.

4.1. Policy mix

4.1.1. Phase 1

Phase 1 of the Ordinance deployed 2 policy mechanisms—bussing station waste receptacles and signage as well as limitations on providing foodware accessories. It required a vendor with a bussing station to have all 3 waste receptacles (compost, recycling, and landfill) with signage (Section 11.64.080). Over the 4 years, there were mixed rates of vendors that had a bussing station, thereby requiring 3 waste receptacles and signage: 89%, 66%, 81%, and 82%. The percentage of those vendors with bussing stations that were fully compliant with the waste receptacle mechanism (i.e., had all 3 waste receptacles and proper signage) was 19%, 16%, 23%, and 25% across the 4 years.

The first phase also required SUD accessory foodware items (e.g., napkins, lids, straws, utensils) to be provided by request or at a self-serve station, not automatically (Section 11.64.030). The rates of compliance by vendors over the 4 years varied by accessory type and are shown in **Table 2**. The percentage of vendors that complied with the accessory mechanism increased from 2019 to 2022 for all recorded accessory types except any bag type (which decreased from 47.1% to 37.9%) and multiple drink holders (remained relatively flat at 18.5% and 17.7%). Napkins, sugar/condiment packets, and utensils had the largest increase from 2019 to 2022, rising by 95%, 72%, and 60%, respectively.

We also captured if employees asked customers if their order was “for here or takeout.” In 2019, 79 (58%) of employees asked about a customer’s order. In 2020 that plummeted to 3 (5%) employees, then in 2021 the number rebounded to 37 (42%) and remained flat in 2022 at 38 (40%). If a vendor did not have on-site dining, they were removed from this specific analysis, as all orders were takeout.

Table 2. Percentage of prepared food vendors serving single use disposable (SUD) accessory foodware items by request or at a self-serve station

SUD Accessory Foodware Item	2019 (%)	2020 (%)	2021 (%)	2022 (%)	% Change Between 2019 and 2022
Cold lids	26.8	16.0	31.5	29.8	12
Hot lids	24.2	17.6	34.7	31.5	30
Napkins	37.6	53.6	78.2	73.4	95
Multiple drink holder	18.5	12.8	16.1	17.7	-4
Utensils	29.3	36.8	58.1	46.8	60
Straws	36.9	30.4	53.2	47.6	29
Sleeve	21.0	14.4	31.5	29.0	38
Sugars/condiments packets	26.8	36.0	51.6	46.0	72
Any bag type	47.1	32.8	37.1	37.9	-20

This chart shows the percentage of vendors surveyed in Berkeley that provided the specified SUD accessory foodware item by request or at a self-serve station over the 4 years of data collection. That approach is compliant with the Ordinance, with a higher rate meaning more vendors comply with regulatory parameters for that SUD accessory foodware item. The column on the far right shows the change in the percentage of vendors complying per item between 2019 (baseline) and 2022 (final year of data collection). In that column, the colors convey the difference in percentage of vendors complying over the 4 years. Orange means there was a decrease in vendors that complied (<0%), yellow means there was a moderate increase in vendors that complied (0%–40%), and green means that there was a large increase in vendors that complied (>40%).

4.1.2. Phase 2

The Ordinance’s second phase integrates 2 further policy mechanisms in the Ordinance’s second phase. The first pertains to the SUDs foodware material type, Disposable Foodware Standards (Section 11.64.070). All SUD foodware must be compostable in the City of Berkeley municipal compost collection programs and not contain any intentionally added fluorinated chemicals. The rate of vendors with compliant SUD cups increased each year: 25%, 28%, 30%, and 44%. The rate of vendors with compliant SUD foodware declined moderately: 54%, 56%, 49%, and 48%. Relatedly, food wrapper material (e.g., the tin foil around a burrito) must be accepted by the City of Berkeley’s municipal collection programs as either compostable or recyclable. The percentage of prepared food vendors with compliant food wrapper material increased from 30% to 80% between 2019 and 2022.

The second mechanism was the imposition of a \$0.25 charge⁹ on each SUD cup provided to customers, notifying them of the charge presale (e.g., on menus and signs) and postsale (receipt) (Section 11.64.050), likely to reinforce transparency about the charge. In 2020, only one vendor mentioned the charge presale and postsale, charged the fee, and accepted a customer’s reusable cup. That is full compliance. In both 2021 and 2022, 3 vendors complied fully. Each year, there were vendors that partly complied

because they either mentioned the charge presale or post-sale, but not both. In 2020, 3 vendors were in partial compliance, in 2021, 4 vendors were in partial compliance, and in 2022, 12 vendors were in partial compliance.

Separate from, but related to, this mechanism is that customers may provide their own reusable cup for beverage service. However, the vendor has the right to refuse it (Section 11.64.040). The rate of vendors accepting a customer’s cup varied over the years, from 56% (2019), 12% (2020), 36% (2021), and 41% (2022), as shown in **Figure 1**.

4.1.3. Phase 3

Phase 3 of the Ordinance focused on reusable foodware (Section 11.64.060). The percentage of compliant vendors with on-site dining and reusable cups went from 46% in 2019 to 61% in 2022. The percentage of compliant vendors with on-site dining and reusable food containers went from 46% in 2019 to 48% in 2022.

In terms of its overall policy mix, as shown in **Table 3**, the Ordinance had 2 policies that were firmly creative, 2 that were partially creative, 2 that were firmly destructive, and 1 that was partially destructive.

4.2. Policy intensity

The COVID-19 orders of March 2020 resulted in the closure of almost all on-site dining. At no point was the Ordinance officially paused or rolled back. However, like other City departments, all previously allocated budget, personnel, and resources were not deployed or were reallocated to support COVID-19 relief efforts, effectively pausing the Ordinance. Prior to the county, state, and federal health orders, the City of Berkeley’s

9. The group that developed and advocated for the Ordinance, in collaboration with the City of Berkeley, intentionally did not make the SUD cup financial mechanism a tax because a tax requires a ballot vote, while a fee is passed through council member delegation, thereby easier and quicker to pass and implement. Additionally, the fee revenue could go to the vendor versus being funneled through the city.

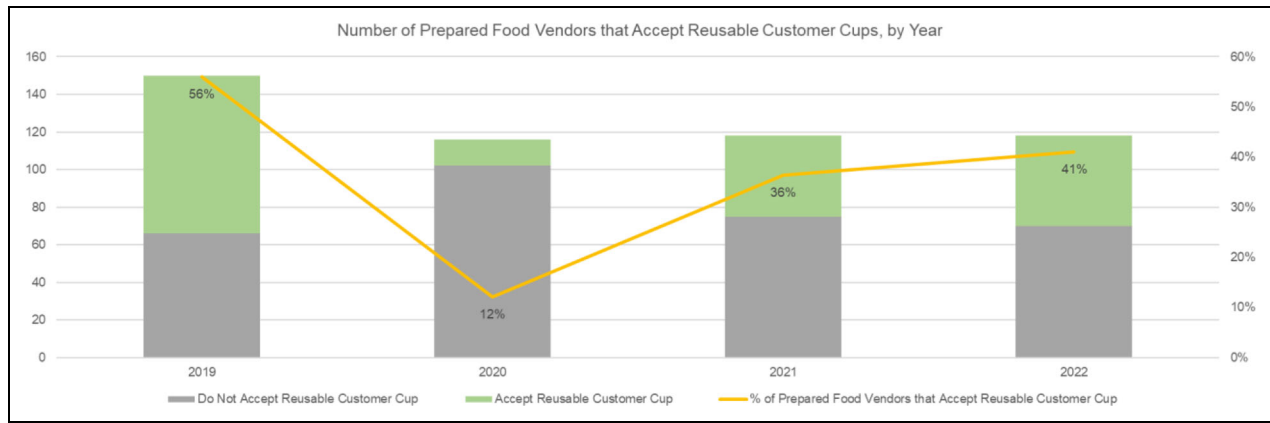


Figure 1. Over the 4 years of data collection, the rate of vendors accepting a customer’s cup fluctuated. It started at 56% in 2019, then dropped to 12% during the height of COVID-19 restrictions and grew to 36% in 2020, then 41% in 2022.

Councilmembers had given the City Manager the responsibility to “determine funding and staffing needs and sources of funds to implement each program/phase” (City of Berkeley, 2019a), which included collaboration between the Department of Planning and Development, Office of Economic Development, and the Zero Waste Division. No formal roles were assigned and published before COVID-19, and there were numerous vacancies in the Zero Waste Division, which was expected to undertake most staffing tasks. Additionally, the 2 staff in the Zero Waste Division at the time were assigned as disaster service workers once COVID-19 began, and the City understandably did not want to impose the extra burden of compliance on vendors who were among the populations hardest hit by the pandemic. Moreover, while the City Council requested the City Manager to set up technical assistance support and a mini-grant program for vendors to comply with Ordinance mechanisms (City of Berkeley, 2019a), neither of those were implemented before COVID-19 orders were announced, or by the final round of data collection in late 2022. The waiver process for vendors to use if they could not comply with the Ordinance was launched before COVID-19 occurred (City of Berkeley, 2022); however, there was little announcement and as of early 2023, no vendor had applied for a waiver.

Table 4 shows how we scored the Ordinance across the 6 measures of policy intensity, including the coding questions for evaluation, the possible score, the coding value description, and the coding value. The coding value, akin to the Schaffrin et al. (2015) study, was calculated based on the representativeness and completeness of the coding value description for the coding question. For instance, 0 meant there were no policy objectives with respect to the policy performance, while 1 meant the policy objective was directly aligned with the policy performance. Only 1 of the 6 measures of policy intensity received full points—integration. The policy was uniquely and firmly integrated with existing policies, was a policy package with multiple mechanisms, and included a policy framework. Objectives and scope received moderate values (0.75) due to the policy’s generalized ambition but specific target (objective) and includes both the supply side

(incumbent SUD foodware producers) and demand side (consumers), but puts an overweighted, or outsized, burden on vendors, even with mitigation actions targeted (scope). Finally, monitoring, budget, and implementation ranked lower (0.5, 0.25, and 0.25, respectively), because monitoring was on an as-needed, complaint-based cadence (monitoring), while there were plans for funding, they were not administered (budget), and there was no clearly defined or operationalized plan for enforcement (enforcement).

4.3. Niche innovation specificity

In the Ordinance, 5 mechanisms aim to foster 3 niche innovations. The 3 niche innovations and their associated mechanisms are (1) fostering reusable foodware through reusable foodware for on-site dining, (2) fostering alternative materials through bussing stations and compostable SUD foodware, and (3) fostering material reduction through a SUD cup charge and not automatically providing SUD foodware accessories.

The mechanism that aims to foster reusable foodware is that all on-site dining must use reusable foodware. Additionally, while not a mechanism, all vendors can accept a customer’s reusable cup. The rate of compliance with the on-site dining mechanism for reusable cups was 46% (2019), 20% (2020), 55% (2021), and 61% (2022) and for reusable food containers 46% (2019), 15% (2020), 38% (2021), and 48% (2022), as shown in **Figures 2** and **3**.

The 2 mechanisms that aim to foster alternative materials are that vendors must have all 3 waste receptacles and signage if they have a bussing station, and that all SUD foodware must be compos in the City’s municipal compost program. So, by creating the infrastructure and requirement for compostable foodware, alternative materials can more easily be adopted. The rate of compliance with the waste receptacle, signage, and bussing station mechanism was 19% (2019), 16% (2020), 23% (2021), and 25% (2022). The rate of compliance with the compostable SUD foodware material mechanism for SUD cups was 25% (2019), 28% (2020), 30% (2021), and 44% (2022) and for

Table 3. Berkeley's Single Use Foodware and Litter Reduction Ordinance mapped onto the policy mix framework

Policy Mechanism Category	Examples of the Policy Mechanism	Represented in the Ordinance and Requiring Vendor Participation
Creative Policies		
Knowledge creation, development and diffusion (C1)	Educational; knowledge creation; data transparency; reference/procurement guides	NO—Vendors must provide “written records evidencing compliance” if a city manager or designated representative requests them, but those records are not publicly available or otherwise meant as a means of knowledge creation/dissemination. Furthermore, there is no avenue to share learnings/successes between vendors.
Establishing market niches/market formation (C2)	Market stimulation; economic policy instruments; public procurement	NO—Public procurement and labeling (the 2 market formation mechanisms in the Ordinance) only pertain to compliant single use disposable (SUD) foodware materials (alternative materials) and do not support vendors.
Price-performance improvements (C3)	Subsidies for learning-by-doing; research and development (R&D) support	NO—While there are grants to support the transition toward compliance, and one local nonprofit funded a pilot of a reusable beverage service, no funding came from the city to support R&D to make innovations price-comparative with incumbent technologies.
Entrepreneurial experimentation (C4)	Diversifying offerings and capabilities; financial investments	PARTIALLY—While authors of the Ordinance and City Councilmembers would like to foster reusable foodware innovation, there is a limited budget and resources dedicated to such experimentation (in the form of technical assistance grants), thereby fostering limited stimulation of entrepreneurship and diversification of existing firms.
Resource mobilization (C5)	Deployment subsidies; low-interest loans; labor-market policies; secondment of expertise	YES—The city offers waivers for noncompliance with either/both the SUD foodware material specifications (compostables) and/or providing reusable foodware for on-site dining. Vendors must apply for the waiver(s), demonstrate need for the waiver(s), and there is a term limit on the waiver(s). PARTIALLY—The city offered technical assistance grants to vendors to support their transition to compliance; however, that was not written into the policy and therefore does not abide by the truth of this category (even if it does abide by the spirit of this category).
Support from powerful groups/legitimation (C6)	Innovation platforms; public procurement; labeling	NO—While there are numerous advocacy organizations and other jurisdictions that are adopting some or all components of the Ordinance, there is no formal or informal legitimization for vendor compliance to the innovations.
Influence on the direction of search (C7)	Nonbinding goals and voluntary actions; targeted R&D funding schemes; tax incentives	PARTIALLY—This policy does not conflict with any stated vendor sustainability goals and in fact likely supports them. It also could influence the direction of the search (if Berkeley is considered a large enough market to warrant vendor search and if there is enforcement to further support vendor search). However, there are no targeted R&D funding schemes, tax incentives, or other proactive attributes that support the direction of search.
Destructive Policies		
Control policies (D1)	Command-and-control; market-based; nudges; quantity limits; material requirements	YES—The ordinance has both a ban (on fossil fuel-based plastics) and a charge (on SUDs cups); there is also a ban on all SUDs foodware items for on-site dining.
Significant changes in regime rules (D2)	Take-back; right-to-repair; shared responsibility; bring your own (BYO); pool system	YES—All vendors that have a bussing station for customers to self-bus their waste must have all 3 waste bins (compost, recycling, landfill); all SUDs foodware accessories must be provided by request only or at a self-serve station.

(continued)

Table 3. (continued)

Policy Mechanism Category	Examples of the Policy Mechanism	Represented in the Ordinance and Requiring Vendor Participation
Reduced support for dominant regime technologies (D3)	Withdrawal support for incumbent technologies	PARTIALLY—The Ordinance does change the preexisting support for incumbent technologies (SUD foodware) by banning such material; however, that change in support is more appropriately categorized under control policies (D1), because the Ordinance does not change the financial legislation for incumbent technologies (e.g., eliminate subsidies for fossil fuel companies).
Changes in social networks, replacement of key actors (D4)	Replacement of key actors	NO—The Ordinance does not influence the social network, replace key actors, or form new organizations or networks.

From the perspective of vendors, the above chart shows which types of policy mechanisms were, were not, or were partially represented in the Ordinance. The Ordinance had 2 policies that were firmly creative, 2 that were partially creative, 2 that were firmly destructive, and 1 that was partially destructive. There are 7 possible creative policies and 4 possible destructive policies.

SUD food containers was 54% (2019), 56% (2020), 49% (2021), and 48% (2022).

The 2 mechanisms that aim to foster material reduction are that all SUD cups have a \$0.25 charge and that all foodware accessories must be provided at a self-serve station or by request only. The rate of partial and full¹⁰ compliance with the \$0.25 charge mechanism was 0% (2019, before the charge was phased in), 3% (2020), 6% (2021), and 16% (2022). The rate of compliance with the foodware accessories mechanism—an average across all accessory types—was 30% (2019), 28% (2020), 44% (2021), and 40% (2022).

5. Discussion

Our longitudinal mixed method study is the first assessment of a multi-mechanism policy approach to reduce SUD foodware waste. Below is a discussion of the results, which map to the 3 research questions, which in turn map to the 3 areas of measuring a STP's effectiveness: policy mix, policy intensity, and niche innovation specificity. All the data and thus results and discussion are positioned around the vendors' compliance with the Ordinance.

Before discussing the results, however, we need to reiterate the profound disruptions caused by the pandemic. With COVID-19 came a flurry of governmental mandates and orders to curb the spread of this novel virus. Vendor sites temporarily or permanently closed, shifted almost entirely to takeout and delivery, and could not accept a customer's cup or bag (Norris et al., 2021). Furthermore, different work types were categorized as essential, meaning food vending employees had to work even with heightened risk exposure (Centers for Disease

Control and Prevention [CDC], 2021). Subsequently, many vendors were hit by the "great resignation" because of poor working conditions (Chaturvedi et al., 2021). They also cut staff because of costs (Riehle et al., 2021) or had to deal with global supply chain issues (Becker et al., 2020). Both vendors and customers feared surface-based virus transmission even after such contagion was scientifically disproved, thereby further discouraging the use of reusable foodware (Thompson, 2020). This prompted the use of SUD foodware, thereby affecting the adoption of 2 components of the Ordinance: that reusable foodware is provided for on-site dining, and that SUD foodware is compostable, which costs more than non-compostable foodware.

Zero waste and anti-SUD foodware policies were paused or not enforced across the United States (Heiges and O'Neill, 2020). The City of Berkeley did not officially pause the Ordinance; however, city staff and resources were allocated to different relief efforts, the previously allocated budget was not deployed, and the Zero Waste Division in the Public Works Department (which manages the Ordinance) could not hire the allotted personnel, so the City did not have the ability to implement or enforce any components of the Ordinance. The Zero Waste Division was still understaffed and without budget when we collected our final round of data in the fall of 2022. However, in early 2023, the Zero Waste Division filled half of the open staff positions and began discussions to monitor and enforce the Ordinance.

We feel the anti-SUD foodware transition was surprisingly resilient and effective given the early and profound stresses of COVID-19. In 2019, the anti-SUD foodware transition was backed with remarkable momentum, shown in numerous local policies, development of alternative materials, and proliferation of reusable foodware systems (Heiges, 2023). Given that the majority of mechanisms bounced back or steadily rose over the 4 years, even amid a global health threat that disrupted all consumption systems, the potential and perseverance of the anti-SUD foodware transition is impressive.

10. For the \$0.25 SUD cup charge, we measured partially and fully compliant because the sample size of fully compliant was so low, that we wanted to include partially compliant as a means to better understand the trend. Fully compliant was if a vendor had the SUD cup charge and mentioned the charge both presale and postsale, while partially compliant was if a vendor had the SUD cup charge and mentioned the charge either presale or postsale.

Table 4. An evaluation of Berkeley’s Single Use Foodware and Litter Reduction Ordinance’s policy intensity

Intensity Measure	Coding Question	Possible Score	Coding Value Description	Coding Value
Objectives	What is the policy objective with respect to policy performance?	0–1	While no specific target is given (which is common), there was a generalized ambition transparent to all stakeholders: to reduce single use disposable (SUD) foodware that is landfilled or improperly disposed of.	0.75
Scope	Does the policy include branches of both supply and demand sides? Are all mitigation actions targeted?	0–1	The policy puts an overweighted burden on vendors for compliance. Incumbent SUD foodware producers have a lot to lose, which resulted in some bargaining/lobbying; however, it was the vendors and disability justice group that objected the most to the initial policy proposal. Mitigation actions were targeted. There could be more economic burden mitigation actions for both the vendor and consumer. The breadth of potential winners is vast and spans economic, environmental, and social.	0.75
Integration	Is the policy mechanism integrated in a package or any reference to other policy mechanisms? Is framework policy included?	0, 0.5, 1	The policy design intentionally aimed to not contradict or conflict with preexisting policy action. As a policy package with multiple policy mechanisms, it increases its likelihood of obtaining the policy’s objective. Framework policy is included.	1
Budget	What are the set expenditures/impositions of the policy mechanism?	0–1	While the Mayor and a City Councilmember referred to Council the need for the City Manager to calculate staff time, costs, sources of funding, and community partnerships, this was never deployed. Set expenditures/impositions of the policy mechanism have therefore not been calculated and/or earmarked. The City is formalizing a partnership to provide technical assistance and financial support via mini-grants to cover one-time costs associated with conversion to reusable foodware. The score is low because while there are plans for such resources, they were not set and administered, in part because of the structure of the Ordinance, and in part because of COVID-19 restrictions. There were waivers available from 2019 for vendors unable to comply with components of the Ordinance, including the cost of making transition.	0.25
Implementation	Is there a statement about implementation procedures specifically allocating actors and rules? How is this implementation planned and is there sanctioning?	0, 0.25, 0.5, 0.75, 1	There is no statement about implementation procedures specifically allocating actors and roles. The City Manager is a catch-all for the majority of City-led items, but there is no specificity in the Ordinance regarding when/how/who, which is common for model ordinances. The expectation was for the Department of Planning and Development, Office of Economic Development, and the Zero Waste Division to discuss roles and responsibilities. The only clearly planned implementation was that enforcement would begin occurring 1 year after enactment and that it would be complaint based. Vendors had an outsized role for implementation; however, there are no clear procedures or guidance on implementation actions for vendors.	0.25

(continued)

Table 4. (continued)

Intensity Measure	Coding Question	Possible Score	Coding Value Description	Coding Value
Monitoring	Is there a specific monitoring process for the policy mechanism and by whom?	0, 0.5, 1	The Ordinance refers to the City Manager to prescribe, adopt, and enforce rules, which include written notice and citation of noncompliance. However, in a Supplemental Packet, there is a note that “[o]nce launched, staff time for administration and enforcement of the Ordinance will be limited” (City of Berkeley, 2019a, p. 3) and that enforcement would be complaint-based. So, while monitoring was assigned, the City knew it was not adequately supported through budget and labor.	0.5

This chart, based on the chart created by Schaffrin et al. (2015), evaluates the strength of the Ordinance’s structure, and thus potential effectiveness, across 6 measures: objective, scope, integration, budget, implementation, and monitoring. The Ordinance has a relatively strong objective, scope, and integration but lacks adequate budget, implementation, and monitoring.

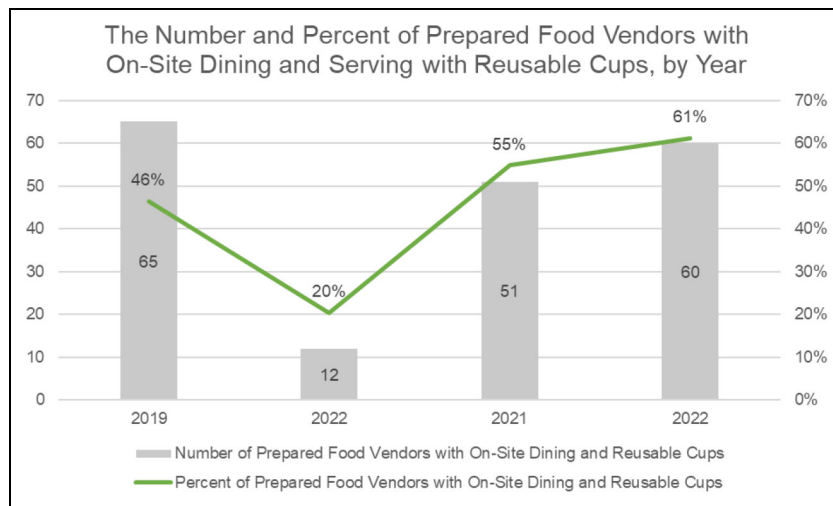


Figure 2. The rate of vendors that complied with the on-site dining mechanism—to serve beverages in reusable cups—was 46% in 2019, 20% in 2020, 55% in 2021, and 61% in 2022. These rates only include vendors that had on-site dining available when data were collected.

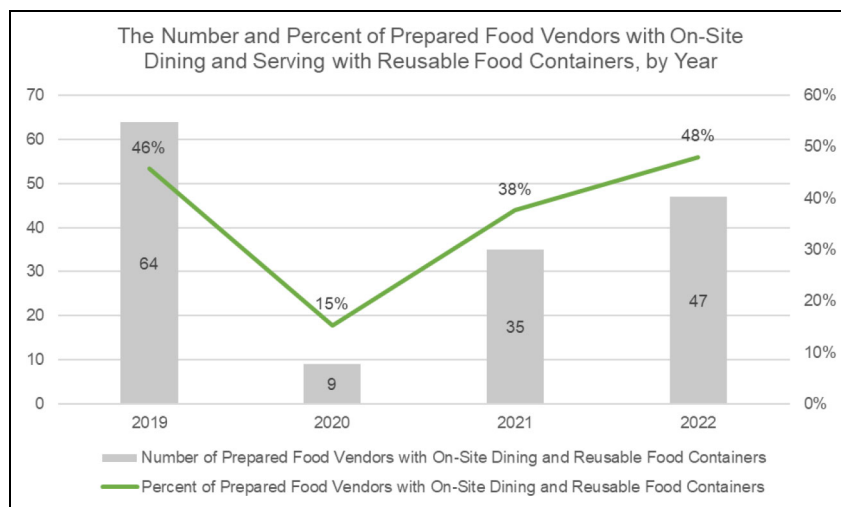


Figure 3. The rate of vendors that complied with the on-site dining mechanism—to serve food in reusable food containers—was 46% in 2019, 15% in 2020, 38% in 2021, and 48% in 2022. These rates only include vendors that had on-site dining available when data were collected.

5.1. Policy mix

In all phases of the Ordinance, rates of compliance grew slowly, if at all (taking only 2019 and 2022 as comparison years). However, compliance was relatively higher at the baseline (2019) and had a strong bounce back rate after COVID-19 (2021 and 2022) for the mechanisms that were already commonly adopted by a vendor or expected by customers. For instance, at baseline, 82% of vendors already had a self-serve station, thereby providing select foodware accessories by request rather than automatically. While the percentage of vendors with self-serve stations dipped in 2020, they rebounded to over half in 2021 (56%) and 2022 (58%). Another example is the percentage of vendors that accept a customer's reusable cup. At baseline, 56% of vendors accepted a customer's cup. In 2020, that rate dropped to 12%, however, by 2021, it was already back to 36%, then continued rising to 41% in 2022. This trend was similar for vendor employees asking if a customer would like their order "for here or takeout" (SUD or reusable foodware). Employees asked customers at 58% of vendors in 2019, but that rate plummeted to 5% in 2020 (mostly because on-siting dining was prohibited), then rebounded to 42% (2021) and 41% (2022).

A final example of this trend of a high preexisting baseline then strong bounce back in compliance post COVID-19 was the percentage of vendors with reusable foodware. Around 46% of vendors already had reusable cups and food containers at baseline. The percentages dropped in 2020 to 20% for reusable cups and 15% for reusable food containers but increased to 55% for reusable cups and 38% for reusable food containers in 2021. The percentage of vendors offering reusable cups and food containers continued to increase in 2022, at 61% and 48%, respectively.

The actions mandated by the Ordinance that were relatively easy to integrate into a vendor's operations had a steadier adoption rise over the years than those that were more challenging to integrate. In 2019, 67% of vendors offering on-site prepared beverages had SUD cups. There was a gradual rise over the 4 years of vendors adopting compliant (compostable) SUD cups. That was a swap of SUD cup material, thereby requiring little operational change, unlike swapping in reusable cups that require dishwashers and staff training, among other adjustments. Compliant (compostable or recyclable) food wrappers also fall into this category and rose substantially during COVID-19, with a compliance rise from 30% to 91% (2019–2020).

The policy mechanisms that required more operational capacity or expense from vendors to implement had declined, plateaued, or little compliance over the 4 years. The main example of this is the \$0.25 SUD cup charge. Implementing the charge accurately requires vendors to update menus, enable the point-of-sale system (cash register) to capture the charge on receipts (paper or electronic), and to train staff accordingly. One interviewee notes that these steps are a significant operational change with associated costs that vendors do not prioritize. Additionally, at least in 2020, since a vendor could not accept a customer's cup nor offer a reusable cup because there

was no on-site dining, and because the piloted reusable cup service program was paused, vendors felt it was not fair to charge customers for a SUD cup when there was no alternative.

Another example of a mechanism not being implemented due to its operational change requirements is if a vendor has a bussing station, they must also have all 3 waste receptacles and signage. In 2019, 94% of vendors with a bussing station had the landfill receptacle. In 2022, not only did fewer vendors with a bussing station have a landfill receptacle (88%), but the percentage of vendors with a bussing station and all 3 waste receptacles only rose from 23% to 26% over the 4 years. Adding more waste receptacles may seem like a relatively moderate operational change, however, vendors do not often provide them, in part, because of the additional operations required to manage them and the high customer-driven contamination rate. If the recycling or composting waste stream was contaminated (e.g., had landfill-based waste in them), the vendor could be fined. Since vendors recognize customer confusion on sorting material by waste stream, they provide the landfill bin by default, which does not have a penalty for material type. As one interviewee noted, even if a vendor complies operationally with the Ordinance, waste stream contamination (which the Ordinance aims to avoid) still occurs because of the customer putting the wrong material in the wrong receptacle, due to the customer's inattention, misinformation, or inaction. To the vendor, especially a vendor struggling with the challenges of rising minimum wages, the labor shortage, and constantly changing regulations because of COVID-19, keeping one, larger landfill receptacle could be operationally easier and more cost-effective.

However, the situation is changing. Additional statewide regulations enacted during the study's 4 years require receptacles at vendor sites and support reduced contamination in waste streams. In January 2020, California Assembly Bill 827—Solid waste: commercial and organic waste: recycling bins (McCarty, 2019) went into effect, requiring vendors to make recycling and composting receptacles available to customers. Then in January 2022, California Senate Bill 1383—Short-lived climate pollutants: methane emissions: dairy and livestock: organic waste: landfills (Lara, 2016) went into effect, requiring organic waste to be sorted via composting, thus creating potential fines for landfill receptacles that collected all material (CalRecycle, 2023). Vendors will therefore have to consider how to address these new requirements in future.

The policy mechanisms that could not be implemented due to COVID-19 restrictions have advanced minimally, if at all. With on-site dining not allowed under COVID-19 restrictions, the number of vendors with SUD cups and food containers rose substantially between baseline and 2020, then remained high through 2021 and 2022. Additionally, of the foodware accessories provided automatically, there were 4 more in 2022 than in 2019 (hot lids, bags, cup sleeves, and multiple drink holders), demonstrating the adoption and continuation of practices that

adhered to the COVID-19 requirements of takeout or delivery only.

A related change in practice around COVID-19 restrictions pertained to compostable SUD foodware material. At baseline, only a quarter of vendors had compliant SUD cup material, while over half of vendors had compliant SUD food container material. Over the 4 years, SUD cup material compliance steadily rose (25%, 28%, 30%, 44%) while SUD food container material compliance increased slightly than dropped (54%, 56%, 49%, 48%). The drop in SUD food container compliance could be due to the large-scale shortage of such material because of supply chain issues (Becker et al., 2020), especially since there was more demand for the items as more vendors were providing SUD food containers (as noted above). Further, one interviewee commented that in the spirit of providing a good dining experience for the customer, they would rather provide a plastic lid than no lid if they no longer have compostable lids.

Overall, the Ordinance is overrepresented on destructive policy mechanisms and underrepresented on creative policy mechanisms. The distribution of mechanisms between firmly and partially destructive and firmly and partially creative influenced vendor responses and participation. There are few resources to support vendor compliance and innovation, but there are numerous actions that the vendors now must do (e.g., 3 waste receptacles) or cannot do (e.g., have noncompliant SUD foodware material).

5.2. Policy intensity

Assessing policy intensity entails assessing a policy's structure to determine its strength and thus potential effectiveness. As described by Zhang et al. (2022), "Policy intensity is an index that weights policy instruments according to measures such as whether the instrument has measurable targets, designated budgets, clear objectives and timelines; its integration with larger policy initiatives; and the enactment of policy monitoring." Structural components include objective, scope, integration, budget, implementation, and monitoring. As of late 2022, the City's Zero Waste Division was still not fully staffed and did not have access to budget and resources previously allocated to the Ordinance for implementation and monitoring, due to COVID-19 orders. This delay in reprioritizing the Ordinance was unlike other jurisdictions across the United States which seemed to reprioritize—by regaining access to staff, budget, and resources—their respective anti-SUD foodware policies in 2021 and 2022. For instance, almost immediately after COVID-19 restrictions ended (and in some cases before they ended), fees and bans were reinstated on SUD plastic bags, SUD plastic straws were not provided automatically, and vendors accepted a customer's cup (Upstream, 2022). In contrast, as of December 2022, the City of Berkeley had not allocated budget to, or made implementation efforts and plans for, monitoring compliance. The delay in reinstating the Ordinance could be, in part, because of the Ordinance's lower policy intensity and the other priorities and mandates the City was facing.

The Ordinance has an *objective* and wide *scope*. Both are transparent and ambitious, though the objective could be more specific. The scope is strong in that it does not create or generate outsized economic winners and losers, and it incorporates mitigation actions, such as allowing vendors to keep the cup charge to offset other compliance costs. However, the city could provide more mitigation actions for the economic burden faced by vendors and consumers. As for *integration*, the policy integrates well without conflict or overlap with other, related policies. Further, as a model ordinance, it includes an overarching framework across multiple agencies.

For *budget*, there was an undisclosed limited and restricted budget for education, awareness, and training; compliance enforcement; technical assistance; a mini-grant program to support vendor compliance; a pilot program; and assessing socioeconomic impacts, as noted in the Councilmember's referrals to the City Council (City of Berkeley, 2019a). However, the budget was not line-itemed toward these different initiatives and was not deployed at the start of COVID-19. This lack of budget allocation is common for model ordinances (Schaffrin et al., 2015), but it greatly reduces the structural strength of the policy. The city intended to provide mini-grants for vendors to cover one-time costs associated with transitioning to reusable foodware. This funding, again, was not deployed due to COVID-19. In early 2023, the city is finalizing a partnership with an outside organization—ReThink Disposables, part of Clean Water Action—to build the program. This revival, however, is now contingent on waste service pricing, which will have a rate increase in 2023 after unusually not having a rate increase for a few years. The Zero Waste Division is funded by that rate revenue. The Ordinance does not collect outside revenue to support City staff time. In contrast, in some other anti-SUD foodware policies, the fees collected from customers (e.g., the 25-cent charge on SUD cups in Santa Cruz County, California), partially or fully go to the city or waste service provider to support waste reduction efforts and policy compliance. In Berkeley, however, the 25-cent charges on SUD cups, which are not taxable, go to the vendors themselves to offset their costs for the more expensive compliant SUD foodware material and to gain vendors' support during the Ordinance's creation. That means in Berkeley, there is no increased revenue generated by the policy to financially support the work.

The Ordinance gave responsibility to the City Manager to oversee *implementation* as a catch-all for monitoring and enforcing. The City Manager is the only stakeholder prescribed for monitoring and enforcement roles, which lowers operating costs (Schaffrin et al., 2015), but overburdens a department that is already resource strapped. The City Manager does not have the authority to direct individual departments (like the Zero Waste Division) and instead is asked to collaborate with departments. As a result, a responsibility gap was created, with the role of key implementing departments not clearly defined. In addition, vendors need to take action to comply with the rule, but their own responsibility is also not clearly defined. For instance, there was vendor and customer

confusion on Ordinance mechanisms, vendor noncompliance with the mechanisms, vendor frustration over the mechanisms, and lack of vendor awareness of the grants and waivers (even though the waiver was included in the initial City notification letters about the Ordinance). This came from (1) the gap in City staff responsibility, (2) conflicting directives vendors received from the U.S. CDC and the City's Health Department, and (3) required vendor action. In addition, implementation was phased in over a 4-year period, with enforcement beginning a year after each phase started. Finally, as one City staff member noted, local governments tend to operate at a relatively slower speed and COVID-19 exacerbated this implementation delay.

The final measure is *monitoring*. Since the budget was not clearly defined, and all available City budget, personnel, and resources were not deployed or were reallocated due to COVID-19, the City has not yet been able to monitor compliance. Further, the City never intended to be particularly rigid in its monitoring and especially did not want to add additional burdens to vendors hardest hit by COVID-19. One media outlet summed up the city's monitoring approach: "The spirit of this legislation is to partner with [prepared] food vendors to make transitions workable—and effective. Implementation is phased, and enforcement of each phase will focus on helping businesses make the transition" (Plastic Pollution Coalition, 2019). This is complaint-based enforcement that deprioritizes punitive measures. It is possible that the lack of monitoring during the data collection period decreased accountability for vendor compliance with the Ordinance.

5.3. Niche innovation specificity

Of the policy mechanisms that aimed to foster 3 niche innovations, all resulted in a higher rate of compliance with the mechanism between 2019 and 2022 and thus advancement for the niche innovation. This was either through bouncing back after an initial drop due to COVID-19 or a steady adoption rise over the 4 years. There was only one submechanism that had reduced compliance from 2019 to 2022. Therefore, the 3 distinct compliance trends are bouncing back, adoption, and reduction.

The first compliance trend is that 3 mechanisms had vendor compliance drop during COVID-19 (2020) but experienced a bounce back in compliance to rates higher than the baseline. These mechanisms were the requirement that only reusable foodware is used for on-site dining (reusable foodware niche innovation); providing all 3 waste receptacles with signage if there is a bussing station (alternative materials niche innovation); and that foodware accessories are provided by request or at a self-serve station (material reduction niche innovation). The latter 2 were incorporated in new California state laws during the data collection time frame. The first, pertaining to the 3 waste receptacles, is covered in both Assembly Bill 827 (McCarty, 2019) and Senate Bill 1383 (Lara, 2016), which went into effect January 1, 2022. The second, pertaining to foodware accessories not provided automatically, is Assembly Bill 1276—single use foodware accessories and standard condiments (Carrillo, 2021). It is

unclear if the passing of these laws influenced compliance by vendors with similar mechanisms in the Ordinance. However, the laws add to the city's mandate to enforce its rule.

The second compliance trend is vendors increasing adoption of the niche innovation policy mechanism over the 4 years. Vendors increasingly complied with the mandate that all SUD cups must be compostable (alternative materials niche innovation), although not with the requirement that all SUD foodware must be compostable. Vendors also began implementing the \$0.25 charge on SUD cups as well as mentioning the charge presale and postsale (material reduction niche innovation). In principle, the reusable foodware niche innovation should also be more entrenched, since the California State Legislature passed in 2019 (Assembly Bill 619—Retail food: reusable containers): multiuse utensils (Chiu, 2019), which allows vendors to accept a customer's reusable cup and food container. However, many vendors have opted not to accept customers' cups and containers due to their own liability and employee safety concerns.

The final trend is reduced compliance with a policy mechanism in 2022 compared to 2019. This only occurred for the mandate that all SUD food containers must be compostable, which is the other sub-mechanism to all SUD foodware being compostable (alternative materials niche innovation).

At the start of the pandemic, all on-site dining was eliminated, third-party reusable foodware providers were revoked, customers could not use their own reusable cup, and the Ordinance was effectively paused. We therefore thought there would be no progress on compliance with the Ordinance and that there would be a large backsliding of the decades-long anti-SUD foodware accomplishments. There was a distinct COVID-19 impact on 2 mechanisms; however, over the 4 years, compliance with the Ordinance improved for almost all elements. There is some progress toward greater use of reusable foodware, material reduction, and alternative materials. The improvements are not necessarily large and there is still, on average, less-than-hoped-for compliance with most mechanisms.

5.3.1. 2023 Ordinance and city staff update

Our data collection ended in 2022. However, many relevant changes to the Ordinance and city staffing have since occurred, prompting us to share an update. In early 2023, the Zero Waste Division was about half staffed and therefore better able to proceed with the staff, resources, and budget originally allocated toward implementing and monitoring the Ordinance. City staff noted that they plan to collaborate with different stakeholders to promote education, awareness, and training on the Ordinance, prioritizing vendors. Additionally, they are formalizing a partnership with ReThink Disposable through Alameda County's Waste Management Authority (StopWaste), on providing technical assistance mini-grants. The city is also in collaboration with a University of California, Berkeley student group, PlateUp, to provide technical and material assistance, funded through the University's Student Environmental Resources Center. Monitoring will have 2

components: City staff will continue to do site visits with vendors for compliance with related policies (composting requirement, SUD plastic bag ban, etc.) and customer complaints will be noted through the city's 311 (information) system. The Ecology Center also plans to conduct monitoring and outreach with vendors. These efforts were absent during the data collection period, and thus provide a new layer of budget, implementation, and monitoring. Furthermore, the city is preparing and formalizing the penalty process, should a vendor fail to comply after receiving a warning.

6. Recommendations

First, we want to acknowledge that a lot of work, consideration, collaboration, and revisions took place to create the Ordinance, which was an unprecedented anti-SUD foodware policy. A thorough dedication to that work can be found in the Ecology Center's Disposable Free Berkeley toolkit (Ecology Center, 2023). Below, we present recommendations to make the Ordinance more effective by increasing vendor compliance. Our recommendations are based on a predominantly quantitative study, conducted right before, during, and immediately after COVID-19. Acknowledging the myriad factors that influence policy impact, while our study incorporates randomized sampling, longitudinal sampling, and mixed methods, our findings about vendor compliance with the Ordinance do not capture all the dynamics at play.

Before we consider the specific recommendations, we want to note that anti-SUD foodware—for the Ordinance and in other jurisdictions—must become more equitable. For instance, if there is a charge on SUD items, customers must have an equitable alternative, and vendors should not be incentivized to implement the charge solely for financial gain.¹¹ The Ordinance made some gestures to equity, such as waiving the cup charge for individuals with WIC and EBT, and requiring all vendors to have SUD plastic straws on-site in case one is requested for accessibility purposes. However, what else can the city do to advance support for those with disabilities to feel included in and cocreators of this movement? Historically, not everyone is included in the early stages of a sustainability transition (Köhler et al., 2019). Berkeley must aim to foster an inclusive sustainability transition.

Currently, vendors have a perverse incentive to continue to supply SUD cups because they can retain the \$0.25 charge. We recommend removing some of this perverse incentive for vendors by funneling at least part of the charge to the city government to financially support waste reduction efforts and/or create additional technical assistance grants for vendors to transition to reusable foodware. This would require a study of how much revenue could be raised and an assessment of the specific initiatives it could support. We also suggest a stipulation that vendors may only implement the SUD cup charge if

they provide compliant SUD cup material and they either have a reusable cup option or accept a customer's reusable cup (Heath, 2023). This has been an issue with one national vendor implementing the SUD cup charge in Berkeley, but none of the elements and expenses that the charge is supposed to cover. Additional ways to make the creative policies stronger are for the city could use funds remitted by vendors to increase and publish data on compliance, build a platform to share learnings and successes, supply financial incentives for implementing reusable foodware systems, and incorporate research and development funding schemes to support vendors in testing innovative types of reusable foodware systems.

We recommend increasing the ordinance's intensity by strengthening its budget, implementation, and monitoring. The budget should include city staff time, physical costs (e.g., flyers educating vendors and customers the Ordinance, technical assistance grants), and ongoing costs (e.g., software and infrastructure for monitoring and enforcement). For implementation, the Ordinance is presently too reliant on city staff as the main actor, since they are the only ones with actionable authority. The city could delegate roles and responsibilities to other key actors of influence. For instance, other actor groups and institutions in the city (e.g., business improvement districts, the chamber of commerce, consumer interest groups, delivery services) could play key roles in helping educate vendors and consumers, defining new norms and practices, and share best practices for cost- and time-effective compliance. However, city staff should continue and increase outreach and education to vendors and customers. For monitoring, we recommend coupling monitoring with other monitoring activities (e.g., for food health and safety, for California's Senate Bill 1383 legislation on compostable food), which the city has informally begun in 2023. Further, as with the ban on expanded polystyrene (EPS) foodware, we suggest formally requiring vendors in their annual business license renewal to comply with the policy, so it demands less city time to collect and analyze compliance rates. Additionally, as with the ban on SUD plastic bags, having progressively larger fines for noncompliance. The nonmonetary consequences for noncompliance should include restricting and/or revoking business licenses and permits.

Finally, our third set of recommendations pertains to fostering a reusable foodware system. To move reusable foodware systems forward, policies such as the Ordinance are essential. However, the Ordinance is too reliant on 2 mechanisms to foster a reusable foodware system: vendors providing reusable cups for on-site dining and customers bringing a reusable cup. Policy to enable sustainability transitions for complex problems must equip all participating actors to participate, develop alternative integrated systems, and sustainably erode the incumbent practices. So, as part of the need to develop alternative integrated systems, the Ordinance needs more alternative reusable foodware system options (e.g., third-party providers, return schemes). This would equip vendors and customers to participate as it would not be a large additional operational item for vendors and it is more equitable for

11. Vendors can be incentivized to implement the SUD cup charge to financially support their transition to compliant SUD and reusable foodware, but the charge should not be a substantial revenue stream.

customers. Further, as a city-managed or city-supported program, it would ensure integration into the consumption ecosystem by involving key actors, developing crucial infrastructure (digital or physical), regulating participation criteria, and potentially subsidizing costs for easier adoption. Finally, by effectively replacing the key prevailing attribute of single use—convenience—it would erode the incumbent practice.

7. Future research needs

Now that COVID-19 lockdown mandates seem to be behind us, we recommend collecting the same data for at least another 5 years to gain insight on the emerging effectiveness trends of the Ordinance. Our study only represents a short-term evaluation of a policy's effectiveness, and there may be different results from a longer term evaluation of a policy's effectiveness (Diana et al., 2022). The city already appears to be implementing some of our above recommendations (that we have given them and that they have received through other forums). Additional years of data collection would clarify whether changing city action influences vendor compliance. That insight, in turn, could inform further adjustments to the Ordinance and similar policies in other jurisdictions.

Further, while it was out of scope for this study, we recommend conducting a thorough comparative evaluation between jurisdictions with an anti-SUD foodware policy and neighboring jurisdictions without one. This “experimental” comparison will better elucidate the impacts of the anti-SUD policy. In addition, it is important to analyze possible interactions between the Ordinance and the subsequent 3 state laws that include anti-SUD foodware mechanisms from the Ordinance: Assembly Bill 827 (McCarty, 2019), Senate Bill 1383 (Lara, 2016), and Assembly Bill 1276 (Carrillo, 2021). Additionally, there were similar policies enacted in 44 other California cities after the Ordinance was passed (Upstream, 2022). So, it would be useful to know if having more neighboring cities with similar policies helps strengthen compliance and reduce leakage.

With regard to the creation or development of similar policies in other jurisdictions, we suggest research to assess the differences between such policies based on that jurisdiction's context. This research could strengthen policies by gaining nuanced perspectives, thus building a more resilient and effective policy-based anti-SUD foodware sustainability transition. Some topics may include the standardization of terminology, what types of vendors must comply with the policy, if there are multiple policies or a multi-mechanism policy, where the SUD foodware charge revenue goes, and if there are rigorous studies that might influence the policy's implementation (e.g., Programmatic Environmental Impact Report). Additionally, we recommend studying EPS bans because that material is no longer prevalent in some jurisdictions with such a ban (Wagner, 2020), thereby demonstrating strong policy effectiveness. Since this study created and leveraged a replicable tool for capturing and evaluating anti-SUD foodware policy effectiveness, we recommend using that

tool to standardize insight and comparability for future, related studies.

In this study, we captured the effectiveness of the Ordinance through vendor compliance. It would also be informative to capture Ordinance effectiveness through waste generation, including the amounts and types of waste generated, which both the city and County plan to do in 2023. Similarly, to obtain a more comprehensive perspective of the effectiveness of the Ordinance, it is important to gain financial data such as the change in revenue and expenses to vendors.

A shortcoming of our research was that it did not include an analysis of SUD foodware waste generated in the delivery process. With COVID-19, there was a proliferation of delivery (by the vendor and with a third-party provider), which likely had different types and amounts of SUD foodware than takeout. Another limitation was our small sample size of interviewees. Early on it became clear that we did not have the time or resources to collect the desired number of interviews and that experts directly involved in vendor operations (e.g., managers at vendors) were difficult to interview because of their limited time. The expert interviews we did conduct were insightful.

8. Conclusion

In January 2019, Berkeley's City Council unanimously approved the Single Use Foodware and Litter Reduction Ordinance. This anti-SUD policy was unprecedented as it incorporated 5 different policy mechanisms aimed to foster a reusable foodware system, alternative SUD foodware material, and reduce SUD foodware waste. The Ordinance was considered a model ordinance for jurisdictions across the world to implement. However, there were no plans to analyze the Ordinance's effectiveness before such implementations were to occur. We therefore conducted this study to inform the direction of this policy for both Berkeley and other jurisdictions to more effectively reduce the amount of SUD foodware waste generated, littered, and disposed of.

The Ordinance required numerous elements—such as new infrastructure, multiple avenues of education, wide scale compliance, and behavior change by all relevant actors—to proceed as envisioned. It may have been possible, but 13 months into the Ordinance's life, the COVID-19 pandemic intervened. The city, rightfully, reallocated budget, personnel, and resources to support COVID-19 mitigation and relief efforts. While the Ordinance was never paused, it was deprioritized. This study, which collected data right before, during, and after COVID-19, demonstrates the effectiveness of the Ordinance amid a pandemic. We attempt to parse out components of the Ordinance's effectiveness but acknowledge that it is all filtered through the lens of the pandemic. It is likely that COVID-19 accentuated weaknesses in the Ordinance versus bolstered any strengths, and it is unclear if those weaknesses would have been prominent without COVID-19.

Our study provides key insights into policies for sustainability transitions. It demonstrates that the use of multiple policy mechanisms can provide a more comprehensive

systemic transition, while knowing that these mechanisms will have varying compliance rates and aid waste reduction in different ways. We demonstrate the importance of fostering multiple niche innovations to increase the effectiveness of a policy and the likelihood of a sustainability transition succeeding. Moreover, while innovative policy can be enacted, weaker institutional support—especially for budget, implementation, and monitoring—may not promote greater compliance with the policy. Our study provides insight into how COVID-19 disrupted the ability and willingness of prepared food vendors (e.g., restaurants, cafés, grocery stores) to comply with different policy mechanisms. Yet, despite these COVID-19 disruptions, vendor compliance with the Berkeley Ordinance did increase—even if only slowly and unevenly—over 4 years, so it is possible to introduce anti-SUD foodware policy at the local level and make progress, even during a global pandemic.

Overall, the Ordinance had a strong mix of policy mechanisms but could include more creative policies to balance the destructive policies. To strengthen the structure of the Ordinance, it needs a clearly defined and allocated budget, implementation, and monitoring. Finally, the Ordinance was novel in fostering reusable foodware, which it should continue to do, but it should be less reliant on that niche innovation and put more financial support and resources toward alternative SUD foodware materials and reducing SUD foodware waste. We hope that the detailed description, analysis, and results of the Berkeley Ordinance will assist other jurisdictions in designing and implementing similar policies toward sustainable transitions, especially in the face of significant external challenges.

Data accessibility statement

Anonymized data: uploaded as online supporting information.

Supplemental files

The supplemental files for this article can be found as follows:

Table S1. The observational quantitative survey.Docx

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Data curation: JH, AP.

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Funding acquisition: JH, MB, DS, KO.

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Approval for human research

This research was approved by the University of California, Berkeley Office for Protection of Human Subjects (OPHS), under their Federalwide Assurance #00006252, and the Committee for Protection of Human Subjects (CPHS). The CPHS Protocol Number is 2020-01-12895.

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Knowledge Domain: Sustainability Transitions

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