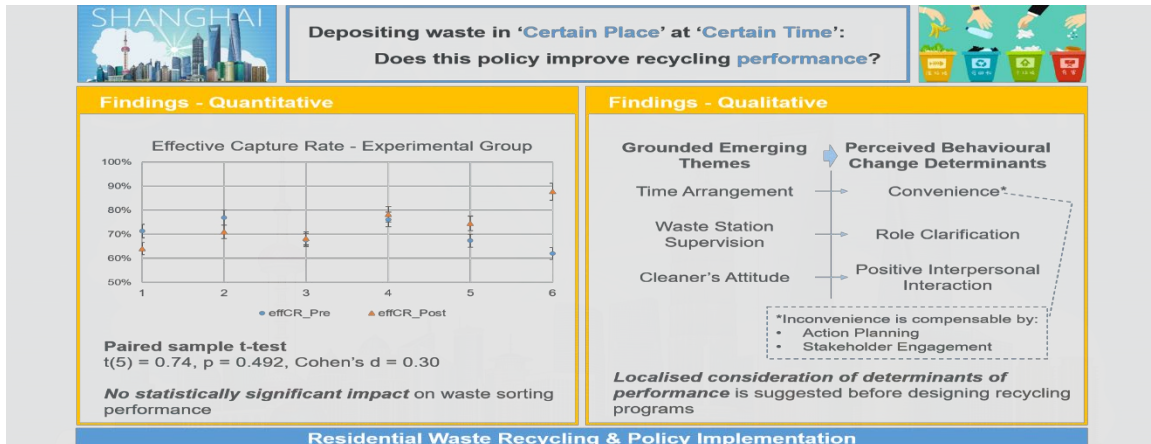


Depositing waste in ‘Certain Place’ at ‘Certain Time’: does this policy improve recycling performance?



HIGHLIGHTS

- The Shanghai ‘Certain Time & Place’ recycling program did not improve sorting
- The program name was a misnomer since most had no new ‘Place’ restrictions
- Restrictions to ‘Certain Time’ (but not Place) did not improve sorting
- No conclusions were possible about Certain Place, which deserves more research
- ‘Deconstructing’ policy elements onto scientific concepts assists understanding

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Depositing waste in ‘Certain Place’ at ‘Certain Time’: does this policy improve recycling performance?

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Abstract

Food waste produces methane in landfills, accounting for 1.5-2.0% of net global anthropogenic greenhouse gas emissions in 2010. In developing countries 40-65% of household waste can be food waste, especially from preparation, since pre-prepared food is less common. Different waste management strategies are used worldwide to get householders to separate out their food waste, including the restriction of permitted times and places for depositing household waste (e.g. 6-7pm daily at kerbside, only). Here we evaluate a Certain Time, Certain Place (CTCP) intervention used across a sample of six communities randomly allocated from a cohort in one district of Shanghai. Mixed methods are used, with directly-measured tonnages pre- and post-implementation, and site observations and open interviews of stakeholders to elicit perceived relevant factors. Quantitative results show no statistically significant impact on waste sorting

performance. Relevant themes which emerged are: time period arrangements; supervision of waste stations; attitude of the assistant cleaners. These are shown to be related to known determinants of Inconvenience, Role clarification, and Positive interactions. Action Planning and Stakeholder Engagement are suggested as mitigators of Inconvenience, but Distance not found relevant. Such deconstruction of policy elements into scientific factors allows a clear scientific perspective: that this CTCP program was almost pure CT only, which increased Inconvenience without giving overall benefits from increasing supervision. Only one community had CP involved, and its performance increased significantly, suggesting CP should be studied further.

In sum, this Certain Place, Certain Time recycling program was actually CT, and is not recommended for increasing food waste sorting performance. The more direct linking of policy elements to scientific factors is suggested as useful for better future design.

Keywords

Waste sorting; Certain Time Certain Place; policy implementation; behaviour change; food waste sorting; household recycling

1. Introduction

China's ongoing urbanization plans for the nation are evident in Shanghai, whose mega-city population now stands at 24 million. With this urban growth is a growth in residential waste, and all its environmental, resource, and cost impacts. Food waste produces methane in landfills, accounting for 1.5-2.0% of net global anthropogenic greenhouse gas emissions in 2010 (Intergovernmental Panel on Climate Change, 2014). Shanghai Municipality has been developing and experimenting for many years, by encouraging interested stakeholders to develop different residential recycling programs. These include personal 'Green Account' incentives using smart cards (Bian et al., 2021; Tian, 2015); third-party involvement of various environmental not-for-profit organizations (NPOs) and businesses in delivery partnerships (SCAB and SLCAAB, 2019); and programs which impose restrictions of 'Certain Time & Certain Place' for residents to deposit their waste and recycling (SLCAAB, 2019). Such programs are complementary to the main core waste management regulations formally implemented starting July 2019, which include city-wide standards of communal bins of standardized colours, specialized vehicles for pickup, and full infrastructure for further processing and final disposal/recycling. Shanghai is an early leader of pilot waste sorting programs, which are commonly adapted by other cities across China. However, scientific evaluation of these various programs is not straightforward for the Municipality to carry out, which makes academic collaboration research such as this study all the more relevant and valuable – for Shanghai and for other cities trying to emulate best practices.

Shanghai Municipality has a goal to increase the participation and non-contamination levels in residential food waste sorting (SLCAAB, 2019). One of several optional and localizable policies suggested to Community Committees for their implementation is named a "Certain Time Certain Place (CTCP)" program for waste deposits of the residents, which restricts when and where residents can drop off their household waste (SLCAAB, 2019). This CTCP policy option was not justified on the basis of evidence or theory, and is counter-intuitive to behaviour studies where the factor of *Inconvenience* is known to be important. However, to some policy makers it is entirely intuitive that residents will make more efforts to sort their waste, e.g. to separate out food waste, if supervision is taking place, and that is only financially viable for short periods and specified sites every day, i.e. minimising the salaried hours of the supervisors.

We give some background on these two worldviews, and on how evaluation of the CTCP concept has been neglected thus far. We then set out how we will evaluate its effectiveness in one district in Shanghai.

1.1 Background

'Certain Places' (CP) are usually waste stations or drop-off points in within the gated community campus, whose number varies according to the population size and space availability but is typically at least one per 300 households living in apartment blocks.

These have been increasingly introduced in Shanghai in the last five years to replace single bins collecting mixed waste which might have been available on every floor of each building, or at the entrance. This centralisation of waste stations was originally pragmatic, as part of a modernisation program whereby the City Municipality wished to introduce separate collection services of recyclables such as plastic bottles and cans, and kitchen food waste. Rather than multiply bins on each floor, waste ‘stations’ with groups of colour-coded bins were provided between buildings, and usually with new or renovated small buildings including a roof and doors of some kind. This centralisation was later found to be very useful when some few communities introduced Incentives Programs, where residents could receive electronic points from a supervisor on a ‘smart card’ for correctly separating their waste before depositing it –this would have not been possible when there were bins inside every building.

‘Certain Time’ (CT) refers to the restriction of the hours those deposit facilities would be available: they would otherwise be closed. This concept has already been experimented or used to different extents: Taiwan famously introduced kerbside collections restricted to a 10-15 minute period when a vehicle visited each evening announced by a loudspeaker (Li, 2017). The reasoning was not theory-based but pragmatic: if people had to individually throw their waste into a supervised receptacle, it was thought it would be better sorted. Several studies showed that the tonnages in the food waste stream in Taiwan increased, but it was not clear that the contamination levels ever improved enough to allow that waste to be usefully diverted from landfill or incineration (Chang et al., 2013; Lu et al., 2006).

The increased usage of both CT and CP together (called CTCP) in China, seems to have occurred not for any clear theoretical or evidence-based policy reason that we can discover. As mentioned above, with the need to modernise waste stations, CP was naturally rolled out. While for CT, some communities initiated an Incentives Program that required staff to sit by the bins and give out ‘green points’ to cooperating residents, and this was more ‘efficient’ if the hours were restricted. Similarly, some communities adopted the use of Volunteers to provide positive interpersonal interaction which was known to be effective (Huang et al., 2018), by standing near the bins at ‘rush hours’ for about three months until a habit was instilled (Xu et al., 2016). Some others used Supervisors. In all these cases, Community Committees may have decided it was more efficient to restrict the hours that residents could deposit waste. Over time, these were presented as ‘CTCP’ programs - whether or not the CT part was intrinsic or advisable.

We have not been able to find any evaluations of CTCP programs. There are ten CTCP papers published in Chinese journals (Chen, 2020; Guo, 2016; Li and Zhou, 2019; Shen et al., 2020; Song, 2019; Wang, 2019; Wei, 2020), but their aim is to describe the existence of CTCP programs, not evaluate them: and then to make policy suggestions. This is the convention in some traditional Chinese journals and society: academics have a clear definitive role to make recommendations for policy on the basis of their good

standing and position, and evidence or argument is not necessarily a part of that (Evasdottir, 2007). Only two of those papers mentioned data (Wang and Guan, 2021; Xi, 2020), both without clear collection or analysis methods. This situation is rapidly changing, however, including with explicit calls from central government to accelerate practices to provide scientific evidence for policy-making (Yang, 2016).

In brief, the effectiveness of a CTCP program has not been demonstrated, and this study's main aim is to systematically evaluate one in a district of the metropolis of Shanghai, using quantitative pre- and post-program direct measures of diverted Food Waste and Residual Waste tonnages. In addition, a minor aim is to explore determinant factors through qualitative observations and interviews.

1.2 Factors to consider as potential determinants

Our exploration of potential determinants of food waste recycling factors is a minor and ancillary part of this study, whose focus is CTCP program evaluation. However, some starting point is needed to decide which to consider. Many factors have been proposed to influence recycling behaviour, including theory-based constructs, such as attitude (Refsgaard and Magnussen, 2009; Tonglet et al., 2004), norms (Barr et al., 2003; Hage et al., 2009), social influence (Abrahamse and Steg, 2013; Barr et al., 2003), and inconvenience (Barr and Gilg, 2005; Garcés et al., 2002; Perrin and Barton, 2001). However, we carried out a systematic review of the hundreds of published papers in major international waste journals since 1990 which report on determinants of residential recycling (not yet published), and found that only 41 of those involved *direct measures* of the behaviour (as opposed to self-reported), and of those, none made use of any theories at all except two which made retrospective checks (Tonglet et al., 2004; Tucker et al., 2001). We found zero examples of behaviour theories being explicitly used in the design of recycling programs, and one paper explicitly detailing UK historical program design for recycling showing it did not use disciplinary theories (Eppel et al., 2013). We consider that there is thus a clear disconnect between theory and practice in residential recycling, and theory is not currently providing for practice-based needs.

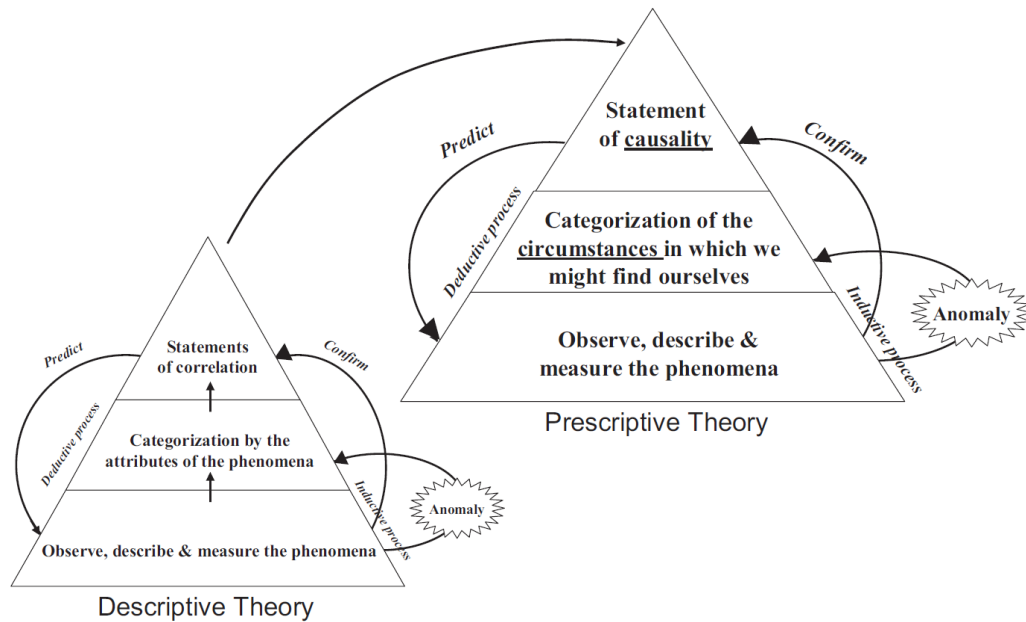


Fig. 1. A framework for theory building from empirical phenomena. Stage 1 involves iterations of exploring attributes of phenomena, and Stage 2, testing causal links within specific Circumstances, to produce a Prescriptive Theory which can prescribe new interventions for new circumstances. Adapted from Christensen and Carlile (2009)

In light of this, our research group is theory building from foundations of empirical research in recycling, following the method of Christensen and Carlile,(2009) shown in Figure 1 and presented in more detail in Li et al. (2021). This will eventually lead to a middle-range theory which is a Prescriptive Theory capable of linking narrow disciplinary theories, to complex practice in the field. In Stage 1, explorations of key attributes of phenomena are identified in a given Circumstance, and then causal tests can be made in Stage 2 (Figure 1). This is consistent to the standard scientific method of first, observations, then testing: but the complexity of the Circumstances in recycling requires multiple iterations in order to pinpoint the key attributes of phenomena. Testing in the field is usually extremely difficult because many factors cannot be held fixed: in particular the collection trucks for different materials arrive at different times and travel different routes, making well-defined measurements for specific target residents very difficult to achieve. However, in Shanghai the standard gated residential communities have provided excellent ‘living laboratories’, and papers have already been published on self-contained studies in Shanghai and Nanjing which established recycling determinants which are increasingly pinpointed: *Social Norms with Emotion* (Dai et al., 2015); clarification of residents’ *Role to recycle* (Xu et al., 2016); *Interpersonal Interaction, Consequences (environmental)* (Dai et al., 2016); Positive versus neutral interactions (Huang et al., 2018); *Incentives, Convenience and Social influences* (Li et al., 2021, 2017); *Stakeholder Engagement, Action Planning, Facilities, and Information* (Xu et al.,

2016).

We believe a very useful final typology of determinants will soon emerge from this ongoing series of exploratory studies, providing a complete ‘checklist’ of determinants as a basis for planning systematic *experimental* field studies of generalisable recycling determinants. However, for this particular study, causal links to specific determinants will *not be tested*: the focus here is on *evaluation of the CTCP program*. Instead, we will use the opportunity to collect further ‘grounded’ exploratory qualitative data and thematically code them, to see if new candidate determinants emerge or whether all the grounded themes align with the determinants already known in our draft typology. Such grounded data might or might not provide insights on determinants involved in current CTCP program, but it will be a useful way to increase Stage 1 explorations of phenomena for the general theory building (Figure 1).

Although the theory-building approach above provides a lens through which to consider determinants of recycling in this study, we still acknowledge other related studies in the literatures. Especially when the time and place of waste deposit are limited, *Inconvenience* for residents would deter participation (Chao, 2008; Garcés et al., 2002; Tonglet et al., 2004). Although distance is a sub-factor of convenience which has been reported on (Dahlén et al., 2007; González-Torre and Adenso-Díaz, 2005; Li et al., 2020; Rousta et al., 2015), we do not expect it to be relevant here because a robust experimental study in similar residential units has already shown the effect to be very small (Li et al., 2020). The CTCP program does, however, involve several community-based stakeholders, and quality of their *Engagement* with residents are likely determinants (Xu et al., 2016). When residents deposit their waste within a shorter period of time (thus with a higher density of people around the bins), they are more likely to meet others, likely triggering *Social Influences* like social norms and *Interpersonal Interactions* (Barr et al., 2001; Li et al., 2017), and requiring *Action Planning* (Knickmeyer, 2020). All of these are candidate determinants known in advance of this study, which are expected to emerge from the grounded data collection here, as long as the interviews and observations are designed to be open, i.e. not eliciting narrowly-defined answers.

In sum, this study has two purposes: mainly, an evaluation of the CTCP program’s effectiveness in one Shanghai district, and, additionally, an ancillary exploration of factors perceived by stakeholders to be related to it. Below we set out the methodology and specific methods, the results and analysis, and then a discussion of the implications to wider research and practice.

2. Methodology

Our methodology is aligned to the recycling behaviour transition (RBT) procedure (Rousta et al., 2016) developed to analyse residential recycling improvements, consisting of 4 consecutive steps (i) current state evaluation, (ii) intervention design, (iii)

intervention implementation, and (iv) post-state evaluation. One difference is that the CTCP program was not specifically ‘designed’ but rather guided by intuition, by local administrations, and implemented by them. The gated residential communities which are typical in Shanghai were taken as units of analysis (Babbie, 2010): their waste can be explicitly, directly measured. For our aim to evaluate the CTCP program, a sample of six communities from a total population of forty which were about to launch the CTCP program were randomly allocated as experimental groups (E-1,2,3,4,5,6). Since communities might have been involved in varying pilot programs historically, it was important to evaluate their current state in detail, and to ensure this was an equilibrium state i.e. no other programs of any kind were introduced recently. Their waste-sorting performance was then directly measured via tonnages and classification of the wastes deposited within 6:30-10:30 am pre- and post- the CTCP launch, and the results analysed for descriptive statistical differences using the paired t-test. Five nearby communities which were *not* scheduled for the CTCP program launch were used for comparison, (C-1,2,3,4,5). They were not controls, but used to provide an indication of the natural variability of the data being collected (tonnages and classification), to ensure the methodology had sufficient sensitivity to changes.

In Shanghai four categories of waste are collected in different coloured bins, with main emphasis on Food Waste bins and the Residual Waste bins: Hazardous Waste bins were also present, but disregarded in this study as they are not often used and are irrelevant to it. Although Recyclables bins were present, residents rarely used them as they can sell such materials directly. In sum, Shanghai Municipality programs focus on diversion of residential Food Waste, not other Recyclables, thus *this study only considered Food Waste and Residual Waste streams*.

In the experimental group of communities, direct measures of tonnages of BOTH these types of bins were taken, within 6:30-10:30 am on one day both before and after their CTCP launch, to provide pre- and post- performances. The local government authority launch was not modified in any way. A compositional analysis of all collected waste was made into the two simple categories of Food and non-Food waste. In the comparison group the same data was collected and analysed on two different days, to provide an indication of natural levels of standard deviation for comparison to the experimental community potential changes. Full details of methods are given below.

A minor aim of this study was to explore candidate determinants. We thus noted CTCP program implementation details and stakeholder perceptions through qualitative grounded approaches including open Stakeholder Interviews and On-site Observations (Babbie, 2010) in three stages: pre- post- and during CTCP launch. The findings were thematically open-coded to maximise findings of any new themes, and subsequently checked against our theory-building draft typology (set out in Introduction) of determinants. Detailed methods are below.

2.1. Site selections

Ideally there would have been random sampling of communities across Shanghai. However, that approach faced several challenges, especially from limitations due to uncertainties of CTCP implementation schedules. Therefore, this work instead took a random sample provided by a third-party local environmental NPO which closely cooperates with government administrations. They nominated six communities (three each) from two Streets (government wards) in Jing'an District, Shanghai, from a total of forty which were about to launch, which they presented to us as 'typical of the mainstream type of communities' in Shanghai in terms of size, per-capita quantities of waste produced, affluence and demographics. Readers not familiar with China should note that it is extremely difficult to obtain accurate official demographic information: having this kind of allocation by a District Government to our study is a significant approximation. The five comparison communities were nominated to us from similar, nearby, communities which were not chosen for any policy implementation at this time. A summary of the characteristics of all communities is given in Table 1: most of this data was not known at the start. In particular it is noteworthy that two of these had previously had a CTCP launch over a year ago, but since then did have any supervision at all of the residents while depositing waste.

Table 1.

Community characteristics and relevant study dates for CTCP experimental and comparison communities. Dates are given as evidence of time to settle down new behaviours – and for future researchers to check against any new related factors that might be thought to be relevant in later years.

	Number of households	No. of buildings* No. of floors	Pre-CTCP program Service Type	Bin types ^b available	Time periods for CTs ^c	No. CP ^d	No. of households per CP ^d	Max distance to CP ^d (m)	CTCP Supervision	Date of data #1 (pre-launch for E)	Date of CTCP launch	Date of data #2 (post-launch for E)	Days since launch
Experiment group													
E-1 ^a	140	3*6	CP only	4 types	7:30-9:00, 12:00-13:00, 18:00-20:00 (4.5hrs)	1	140	100	Full time	30, June, 2020	1, July, 2020	14, October, 2020	105
E-2 ^a	168	1*22	CP only	4 types	6:30-9:00, 12:30-13:00, 18:30-21:00 (5.5hrs)	1	168	20	Full time	14, July, 2020	15, July, 2020	13, October, 2020	90
E-3 ^a	387	1*32, 1*25	CP only	4 types	7:00-9:00, 12:00-13:00, 18:00-21:00 (6hrs)	3	129	50	Occasional	21, July, 2020	1, August, 2020	16, October, 2020	76
E-4 ^a	320	1*23, 2*6	CP only	4 types	6:30-9:30, 18:30-21:30 (6hrs)	1	320	70	Full coverage	11, August, 2020	15, August, 2020	20, October, 2020	66
E-5 ^a	918	23*6	CP only	4 types	6:30-9:30, 18:30-21:30 (6hrs)	3	306	70	Occasionally	22, July, 2020	27, July, 2020	15, October, 2020	80
E-6 ^a	518	15*6	No CP ^e , No CT	4 types	6:30-9:00, 18:30-21:00 (5hrs)	3	173	150	Occasionally	23, July, 2020	30, July, 2020	15, October, 2020	77
Control group													
C-1 ^a	109	2*6	CP only	4 types	24/7	1	109	40	N/A	18, August, 2020	None	3, September, 2020	N/A
C-2 ^a	280	3*7	CP only	4 types	24/7	1	280	50	N/A	23, October, 2020	None	29, October, 2020	N/A
C-3 ^a	190	1*8, 1*11	CP only	4 types	24/7	4	48	30	N/A	27, October, 2020	None	29, October, 2020	N/A
C-4 ^a	218	3*18	CTCP ^f	4 types	7:00-9:00, 18:30-21:30 (5hrs)	1	218	30	None since 2019	4, August, 2020	Historical (2019)	20, August, 2020	~400
C-5 ^a	2000	1*7, 1*27, 3*22	CTCP ^f	4 types	7:00-9:00, 18:00-20:00 (4hrs)	3	667	60	None since 2019	12, August, 2020	Historical (2019)	19, August, 2020	~400

^a E = experimental group; C = comparison communities

^b Bin Types: by law, every community should have 4 types of bins for sorted deposits of: Hazardous, Recyclables, Food Waste and Residuals. The Recyclables bins were rarely used since residents can sell them on directly.

^c CT means restricted times for waste deposit

^d CP means designated drop-off points (waste station), evenly distributed within the residential community

^e The was effectively no CP, since there were so many waste stations (8 for the 15 buildings, 40m distance max) in the pre-stage. At the post-stage these were reduced to 3 waste stations (max 150m distance).

^f CTCP but without supervision

2.2. Data collection

2.2.1 Waste sorting performance

We used very discerning measures to evaluate the residential waste sorting performance. In every single community, ALL of the waste deposited between 6.30-10.30am on one morning pre- and one post-, was collected, from the Food Waste and Residual Waste bins. Communities with CTCP usually use a two-hour window within this period for their restricted CT time periods (details given in Table 1).

Other studies sometimes use Capture Rates (Dahlén, 2005), which show the amount of a specific material e.g. food waste which is captured in the designated bin – as a percentage of the total amount of that material found in ALL bins:

$$CR_{FW} = FW / FW_{total} \text{ in all waste} * 100\%$$

where FW denotes the weight of food waste in recycling bins (with any contamination removed), and FW_{total} denotes the weight of total food waste found in all types of bins.

However, the above Capture Rate does not take into account the Contamination Level (of food waste bins) which represents the purity of recyclables (food waste), calculated as:

$$\text{Cont.L} = [(nonFW) / (FW + nonFW) * 100\%] \text{ recycling bins}$$

where nonFW denotes the weight of contaminations (waste types other than food waste) in food waste bins.

We do not rely on these alone, because in some circumstances measures of only CR_{FW} and Cont.L could be ineffective in describing actual waste sorting performance. This is because, if food waste in food waste bins were pure, and other bins contained food waste mixed in, then Cont.L would equal to 0 (best scenario for food waste bins) yet CR_{FW} could still be low. Conversely, if food waste bins were badly contaminated and other bins were without food waste, then CR_{FW} would equal to 1 (falsely indicating high performance), yet Cont.L would still be high and the material of too low a standard to process for recycling. Therefore, we use the *Effective Capture Rate*, effCR (Huang et al., 2018; Lin et al., 2016) as a much more useful indicator, which combines CR_{FW} and Cont.L:

$$\text{effCR} = \beta CR_{FW}$$

where $\beta = (\text{proportion of } nonFW_{total} - \text{Cont.L}) / (\text{proportion of } nonFW_{total})$ and where $(\text{proportion of } nonFW_{total}) = nonFW_{total} / (nonFW_{total} + FW_{total})$, and $nonFW_{total}$ denotes the weight of total non-food waste found in both types of bins.

To ensure that the waste tonnage and composition data collected was truly representative of the residents' efforts, we made arrangements with the community cleaners and supervisors so that they did NOT intervene in any way which might change anything. This was necessary because they otherwise did occasionally check the bins

after residents made deposits, and execute what we term, ‘second sorting’. This was therefore controlled in this study.

2.2.2 Stakeholder interviews and site observations

In order to collect rich exploratory information suitable for grounded analysis of emerging themes, in-depth semi-structured interviewing (Babbie, 2010) was used with community-level stakeholders both pre- and post- CTCP launches: residents (as obligated sorters), volunteers and cleaners (as sorting assistants), and the Community Committee (CC) and Housing Association (HA) (as community management partners) (Xu et al., 2016). For each experimental community we interviewed at least 20 residents (5-15 minutes each), and at least 1 of all other stakeholder types (20-40 minutes each). This approach was to provide information for triangulation about the program’s implementation and perceived pertinent factors. Readers should note this approach is not intended to be representative: the aim is to generate a saturation of concepts from a range of participant types.

Semi-structured open-ended interview questions (Babbie, 2010) were designed to elicit as broad a range of themes as possible, but to at least those cover those which we knew from the draft typology mentioned in the Introduction: Convenience, Action Planning, Stakeholder Engagement, Role, Emotion and Interpersonal Interaction. The questions are listed in the Supplementary Information (Appendix I). Additionally, implementation plans, preparation works, implementing progress, and changes of plans were actively checked to ensure no anomalous processes occurred in one community compared to others.

Non-interventional on-site observations were conducted pre-, post- and during CTCP launches. Any unintentional interference from researchers - even talking to residents occasionally - could jeopardize the experimental results. Therefore, until the post- period, researchers avoided interacting with anyone on site. Observations cannot be completely open-ended, as this is operationally impossible, but the determinants from the draft typology suggested that for Service, Facilities and Convenience details the following observations would be minimally needed: deposit times (CT), number and locations of waste stations (CP), maximum distances to the waste stations, number of buildings and floors for each community, waste sorting participation of residents, miss-time bags (numbers of waste bags left by the bins after the station is closed), volunteer shift times, and actions of management.

2.3. Data analysis

The quantitative data on performance was designed to yield descriptive statistical information on the program’s effectiveness via the Effective Capture Rate (effCR) calculated pre- and post-CTCP. This was calculated using the definitions above, by

collecting ALL waste in BOTH types of bins, for the total morning collection in each community, twice, and separating out the composition by hand sorting into the two categories of Food, Residual Wastes. Comparison community effCR data was derived from two independent measures in each of five communities to provide indicative standard deviations of effCR.

The ancillary aim was to explore which of the CTCP program elements might trigger determinants of behaviour change. For this, the qualitative data from the Stakeholder interviews and on-site was thematically open-coded (Babbie, 2010), first within each community and then across the six, in iteration, to generate grounded emerging theme clusters. The coding was carried out independently by two researchers who then compared notes and resolved differences. These themes were then each considered qualitatively for potential causality towards recycling performance, to inform the design of future studies. It was not anticipated, but in fact the analysis was extended to include a ‘scoring’ of the strength of each theme found to be a barrier or driver of better performance in each community. Finally, those themes were also compared to the determinants of our draft Typology to consider if any indicated new concepts. These are all described more fully in Results.

3. Results and Analysis

ALL of the Food and Residual Waste deposited in the morning periods was collected in each community, pre- and post-launch of the CTCP program, and hand-sorted for compositional analysis to determine how much Food Waste and Residual Waste was in each bin type (Table 2 below).

Table 2.

Waste composition (kg per morning collection within 6:30-10:30 am) in Food Waste and Residual Waste bins in each community (pre- and post for Experiment communities and two measures for Comparison communities to obtain indications of natural variation).

Community	No. of Food Waste bins collected	Total waste (in FW bins)	Food Waste (in FW bins)	Contaminant Residual waste (wrongly in FW bins)	No. of Residual Waste bins collected	Total waste (in RW bins)	Residual Waste (in RW bins)	Food Waste (wrongly in RW bins)
1st measurement (pre-launch)								
E-1	1	41.64	39.84	1.80	2	53.96	43.06	10.90
E-2	1	27.92	26.72	1.20	2	35.08	30.06	5.02
E-3	2	26.06	25.98	0.08	4	49.86	37.62	12.24
E-4	1	46.04	45.60	0.44	4	71.46	58.28	13.18
E-5	1	38.14	34.80	3.34	2	37.50	30.66	6.84
E-6	2	25.02	23.42	1.60	5	32.34	23.50	8.84
2nd measurement (post-launch)								
E-1	1	26.06	25.20	0.86	3	62.90	50.94	11.96
E-2	1	26.12	25.54	0.58	2	42.98	34.14	8.84
E-3	2	26.06	25.72	0.34	5	68.46	57.30	11.16
E-4	1	35.04	34.82	0.22	3	51.42	42.32	9.10
E-5	3	55.14	53.20	1.94	5	64.70	52.06	12.64
E-6	2	64.90	64.32	0.58	5	69.43	61.81	7.62
1st measurement								
C-1	1	11.86	11.68	0.18	1	17.44	15.30	2.14
C-2	1	15.84	15.40	0.44	2	24.76	21.80	2.96
C-3	1	32.82	31.90	0.92	1	20.18	15.30	4.88
C-4	1	30.50	30.16	0.34	2	22.56	19.86	2.70
C-5	2	38.78	38.08	0.70	2	28.52	25.96	2.56
2nd measurement								
C-1	1	15.02	14.68	0.34	2	18.26	15.56	2.70
C-2	1	22.52	22.02	0.50	3	28.30	25.42	2.88
C-3	1	19.02	18.58	0.44	2	20.54	17.48	3.06
C-4	1	30.60	30.06	0.54	1	24.48	22.06	2.42
C-5	1	45.62	44.42	1.20	1	38.84	35.64	3.20

3.1. Performance Data: *effCR*, *CR_{FW}* and *Cont.L*

The analysed results from the Comparison Communities (Table 3) demonstrated what we'd hoped for: a low standard deviation across all measures, of only 1.4 maximum. This implies that our methodology for measuring performance is intrinsically suitably stable for showing differences between pre- and post- CTCP program analysis. This had to be checked because in other contexts, e.g. typical in many other countries, this might not have been the case e.g. if residential compounds were not fenced then use by 'outsiders' could have caused variations.

Table 3

Food Waste Capture Rates, Contamination Levels and calculated Effective Capture Rates of the Comparison Communities (n=5) derived from direct measures of waste tonnages and composition given in Table 2. They each had two sets of independent measures taken to indicate natural variability (standard deviation) of measures.

	C-1	C-2	C-3	C-4	C-5	Avg Stdev
effCR_1st	82%	80%	79%	89%	89%	
effCR_2nd	80%	85%	81%	89%	88%	
Averages (rounded)	81%	83%	80%	89%	88%	
Standard deviations	1.4	3.5	1.4	0.0	0.7	1.4
CR _{FW} _1st	85%	84%	87%	92%	94%	
CR _{FW} _2nd	84%	88%	86%	93%	93%	
Standard deviations	0.7	2.8	0.7	0.7	0.7	1.1
Cont.L_1st	2%	3%	3%	1%	2%	
Cont.L_2nd	2%	2%	2%	2%	3%	
Standard deviations	0.0	0.7	0.7	0.7	0.7	0.6

The Experimental group's analysed results are given in Table 4. The Effective Capture Rate is the key indicator: it incorporates the other measures (but those are still provided for researchers who wish to make other types of comparisons). The changes in effCR are seen to average out to almost nothing. A paired sample t-test of the effective Capture Rate effCR across the 6 experimental communities, using the SPSS 22 software, showed that the introduction of the CTCP program had no significant impact on the overall improvement of waste sorting performance in those communities (which comprised a random sample from the District): $t(5) = 0.74$, $p = 0.492$, Cohen's $d = 0.30$.

However, one community amongst those six – E6 - showed a large positive change of 26 % points improvement (Figure 2). Its individual consideration is given in the Discussion.

Table 4

Pre- and post- program launch, performance indicators, and their changes, for communities from the Experimental group E (n=6). A paired sample t-test showed no

significant change across them.

Indicators	E-1	E-2	E-3	E-4	E-5	E-6	Average	Standard Deviation
effCR_Prior	71%	77%	68%	76%	67%	62%		
effCR_Post	64%	71%	68%	78%	74%	88%		
Δ effCR	-7%	-6%	1%	2%	7%	26%	4%	12%
CR _{FW} _Prior	79%	84%	68%	78%	84%	73%		
CR _{FW} _Post	68%	74%	70%	79%	81%	89%		
Δ CR _{FW}	-11%	-10%	2%	2%	-3%	17%	-1%	10%
Cont.L_Prior	4%	4%	0%	1%	9%	6%		
Cont.L_Post	3%	2%	1%	1%	4%	1%		
Δ Cont.L	-1%	-2%	1%	0%	-5%	-6%	-2%	3%

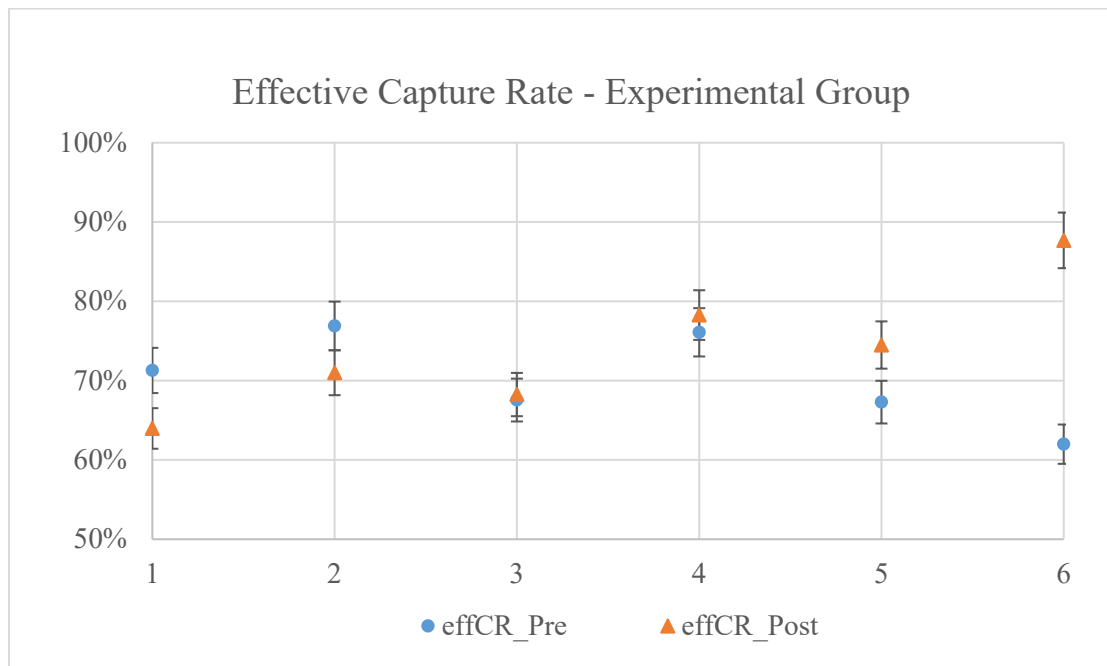


Fig. 2. Pre- and post-performance (effCR) changes, for communities from the Experimental group E (n=6).

3.2. Explorations of determinant factors

Qualitative data from both stakeholder interviews and on-site observations were analysed together for each community and organised into themes. The data was then considered across all six communities and open-coded from the emerging themes (Babbie, 2010): this involves collecting them all and iteratively using constant comparison to determine if a theme needs modifying or a new one added. Two researchers did this independently and then compared results, finding no important differences. The entire set of data was then re-coded with the final and complete theme list. Examples of evidence for each of them is given for illustration in Table 5 for the example of E-1.

On completion of that analysis, a further analysis was found to be possible: to qualitatively 'rate' communities on the approximate strength of each theme being a hindrance or driver of better recycling performance, or neither, (rated '-', '+', and '0' respectively). This is purely heuristic, to provide a feel for the data, which is only exploratory in nature. Only strong factors (indicating big changes) are indicated, positive or negative: small changes were not shown since the method is very coarse. For illustration, the ratings assigned for all themes in E-1 are given in Table 5. Table 6 gives examples illustrating benchmarks for each rating for each theme.

Table 7 shows this form of analysis applied *across all the six* communities, providing a 'profile' of them. No individual characteristic stands out as a strong candidate correlated to recycling performance.

Table 5

Rating of hindrance or driver levels, ‘-’, ‘+’, and ‘0’, of all grounded themes of in Community E-1, with examples of evidence from interviews and observations (see Supplementary Information-Appendix II for the full list of all evidence).

Grounded Themes	Rating	Researchers reasoning	Evidence
Time Arrangements	‘-’	Inconvenient for many residents. Residents emphasized the inconvenience and also that management refused to make any changes	Resident interview: <i>“...my workplace is quite far from here, so I have to leave early. But the station won’t open until 7:00 am...”</i> <i>“...I am a ‘996’ worker (9am-9pm, 6 days/week), I come home late and I’d like to sleep late next morning, so I always miss the CT and have to store my waste for many days...”</i>
Waste Station Coverage of Compound	‘0’	There is only one waste station in the central area of E-1 community	On-site observation: No change during CTCP implementation.
Waste Station Upgrades	‘0’	There was a reconstruction in 2019, before the launch the new waste law. The station gate was re-painted, and lights and hand washing sink were installed. It had not been changed since then	On-site observation: No change during CTCP implementation.
Serious Launch	‘+’	It possesses factors perceived by residents to lower conflict of CTCP launch, involving serious door-stepping, obvious publicity materials, designated activities, big coverage, etc.	Resident interview: <i>“...Yes, I know CTCP is about to launch, CC and volunteers came to my door the other day...”</i> <i>“...of course I know...well, I learnt about that by the notice sticking on our building entrance. I believe everyone can see it, you cannot miss it...”</i>

Flexibility of Administration	‘-’	CC and HA ignores residents’ complaints and ran CTCP really strictly	Resident interview: “... <i>certainly, we have filed complaint about inconvenient timing to the CC’s office, but we have been told that this is the decision of upper level government, which they cannot overrule...I think this is just ‘sloth administration’ (prevaricate with excuses)</i> ”
Station Supervision	‘-’	No interaction with residents who litter waste after CT or sort for residents are believed no helping for behaviour change of residents	On-site observation: The cleaner looked exhausted and listlessly did her/his work. When residents came down late and left waste bags by the station, the cleaner just picked it up and stored in a small room next-door (waste station is not allowed to be opened during non-CT). Within CTs, if residents handed over their waste to cleaner, the cleaner would always take over and sort for them
Cleaner’s attitude	‘-’	Every time we went to E-1 community, the cleaner complains about her/his unjust situation to us	Cleaner interview: “... <i>the HA manager yells at me every day, every time when I was trying to help resident, the words he used are unspeakable, I hate him...</i> ” On-site observation: “ <i>Go to hell!</i> ” mumbling by the cleaner, right after their HA manager lectured the cleaner with a very strong tone.
Adaptability of residents	‘-’	The issue of littering is very obvious	On-site observation: Many residents litter waste bags by the bins during non-CT instead of changing their schedules to the CT. Gathering of residents complain about CTCP.
Deposit density (related to lifts)	‘0’	6-floor building (Table 1) with relatively low density of households	On-site observation: No obvious change during CTCP implementation.

Table 6.

Grounded Emerging Themes from the Certain-Time, Certain-Place program’s qualitative data (interviews and observations). Examples for ‘benchmarking’ of the strongest drivers (rated as “+”) and strongest barriers (rated as “-”) to improved sorting

performances are given for each. ‘0’ indicates no perceived influence.

Grounded Emerging Themes	Examples of Strongest Barriers (rated as “-”)		Examples of Strongest Drivers (rated as “+”)		Range Found ^b
Time arrangements	Time set is inconvenient and no adjustment made; no designated plan made for residents who cannot follow CT (determined by the numbers of waste bags left by bins)	E-1	Time is set according to residents’ votes; modified according to implementation realities; convenient for most; Overtime plans made	E-6	(- to +)
Coverage of waste station	Inconvenient for many of residents (including bins reduced after CT); or too convenient for many outsiders	E-6	Unchanged since CTCP launch	E-3	(- to 0)
Waste station upgrades	Non-change from CTCP launch	E-2	User-friendly reconstructing, including light, sink, roof, space, etc.	E-6	(0 to +)
Serious launch	Mild launch; small coverage	E-4	Serious door-stepping; obvious publicity materials; designated activities; big coverage	E-1	(0 to +)
Flexibility of administration	CTCP implementation causing conflict between residents and administration	E-5	Administration are able to identify implementation problems, flexible to make changes, and able to fix problems	E-6	(- to +)
Station Supervision	Severe interference such as public sorting, takeover, etc. during CTCP	E-4	Cleaner, scanner, volunteer, or CC, HA, SG’s watching, persuading, and educating without assisting, or almost non-intervention due to subjectively avoiding or lack of time and space	E-5	(- to +)
Cleaner’s attitude	Negative attitude such as anger, frustration, etc. towards CTCP or administration	E-1	Positive attitude towards CTCP or administration	E-6	(- to +)
Adaptability of residents	Discontents making negative actions (bags littering, public speech) that cause negative impacts	E-5	Residents are supportive or obedient, and adapt to the changes easily	E-6	(- to +)
Deposit density ^a (related to lift)	Higher density of waste deposits during Certain Time (caused by narrow CT, few lifts in tall buildings) which then allows residents to ‘cheat’	E-2	No obvious change, or low density	E-5	(- to 0)

sorting

^a Deposit Density is the term we use to communicate the ‘density’ of residents that are likely to be near the waste stations in the time window allowed: this is dependent on the number of lifts in tall buildings.

^b ‘0’ in the range means no change or negligible changes from CTCP implementation.

Table 7

Comparison of heuristic ratings of hindrance or driver levels, ‘-’, ‘+’, of all grounded themes across all Experiment communities. A blank denotes ‘0’ i.e. no drivers or barriers were mentioned, those in bold display variations roughly correlated with the variations in recycling performance achieved.

Grounded Emerging Themes	E-1	E-2	E-3	E-4	E-5	E-6	Range
Time Arrangements	-				+	+	(- to +)
Coverage of Waste Station						-	(- to 0)
Waste Station Upgrades						+	(0 to +)
Serious Launch	+	+	+			+	(0 to +)
Flexibility of Administration	-	+			+	+	(- to +)
Station Supervision	-	-		-	+		(- to +)
Cleaner’s Attitude	-	-			-	+	(- to +)
Adaptability of residents	-	+	+		-	+	(- to +)
Deposit density (related to lifts)		-	-	-			(- to 0)
Sum of scores	-4	0	+1	-2	+1	+5	
ΔeffCR^a (for reference)	-7%	-6%	1%	2%	7%	26%	

^a Extracted from Table 4 for comparison with the Sum of marks

4. Discussion

4.1. CTCP intervention: overall ineffectiveness

The quantitative results from paired t-test of the prior- post- CTCP launch Experimental group (Table 4) show that the CTCP program, in and of itself, had *no statistically significant impact* on the overall improvement of waste sorting performance.

What needs to be further discussed, is: what does this actual tell us in terms of policy, and in terms of the ‘science’ of recycling?

In terms of policy, the result is important because evidence-based program evaluation is yet a developing field in waste management in China: it is more traditional to defer to good reputation and expertise than to request evidence in the form of reproducible data. Thus, other cities have already been recommended to copy the ‘CTCP program of Shanghai’ (Sustainable Behaviour Research Group, 2020), characterised by restricted numbers of central waste stations which are only open and supervised for restricted periods of 3-5 hours per day. To a policy maker the logic appears intuitively simple: if every resident’s waste deposit is supervised, and the cost of that is reduced by restricting hours, then excellent recycling performance should result at low cost.

However, the results here do not support this CTCP concept is useful – at least in this district. The only community with a large improvement in performance was E-6 - and the supervision there was *only occasional* (the assistants rotated between waste stations, leaving them unsupervised in between). Furthermore, anecdotally, all of the comparison communities had *no supervision* but had higher performances.

Of course, it could be argued that various ‘social’ or ‘demographic’ factors might cause these results, but that confuses the units of analysis: the evaluation was of the program, across a district, regardless of the internal differences in each community. In that sense, CTCP as a program was not successful in increasing performance, directly measured in tonnages.

The second question is, therefore: were there differences in the communities which could suggest reasons for the varying results? To answer this, we turn to the rich exploratory qualitative data and try to draw out patterns for future studies focussed on testing candidate factors. Table 7 shows in bold the themes which emerged from the interviews and observations, which have trends in line with recycling performance improvements. Below we discuss each them, and link them to determinants which are well-known from other literature, including our systematic studies in China.

4.2. Community profiling using grounded themes

Table 7 shows the meta-analysis undertaken, by considering the patterns of findings from the range of factors of note from stakeholder interviews and on-site observations. No single one of them dominate the post-CTCP changes in performance either in individual communities or across them. However, it can be seen that three themes are roughly correlated with performance increases, and deserve further exploration: Time Arrangements (for the restricted Certain Time), Station Supervision, and Cleaner's Attitude.

4.2.1 Time arrangements for the CT

The restriction of the time periods for waste deposits was clearly inconvenient for many resident types, such as night-shift workers, part-time A-Yis (female housekeepers), weekend slug-a-beds, etc. Previous studies suggest that Inconvenience affects the willingness of recycling, and hinders participation (Chao, 2008; Garcés et al., 2002; Li et al., 2021, 2020; Tonglet et al., 2004). This was especially suggested in our E-1 case from the interview data: the community management failed to modify the time arrangements on request. The overall effective Capture Rate decreased by 7%, and Contamination Levels worsened. This study does not reveal causality, but there are several factors known to be linked to similar situations. For example, individuals can easily 'cheat' or free-ride (Midgley and Olson, 1969) when larger numbers deposit in short periods at fewer designated places. Some may argue that crowds (higher deposit density) generates stronger social norm effects that enhance recycling (Joseph, 2006; Kaplan Mintz et al., 2019), while others suggests that norms might be ineffective in such a collective action (Carlson, 2001), especially when the desired behaviour is relatively inconvenient (waiting in line for drop-off) or requires effort (emptying food waste out of its bag into bin).

In other communities in our study, however, the potential Inconvenience was mitigated. For instance, the managers of E-4 and E-5 provided overnight bins, while E-3 carried out thorough engagement exercises with residents to optimise the set times, and managers in E-6 carefully considered Inconvenience when they chose to set up a new, user-friendly waste station at the main entrance. A study by Li et al. (2020) showed that once behaviour is formed after a certain period of time, the potential inconvenience of an increased distance was no longer reported – although it might reduce initial participation very slightly. Therefore, it seems that the impact of the Convenience determinant is present in CTCP (from the trend in Table 7), but mitigatable.

Another determinant closely connected with Convenience is Action Planning,

which requires effort for both community administrations and residents. For community administrations, there are many challenges were faced in planning and implementing such restrictions, such as the choice of time set and location of stations, publicity measures, conflict resolutions, etc. Knickmeyer (2020) suggests that preliminary investigations and stakeholder consultations are useful, and did seem effective in E-6, where plans and decisions were made with in-depth involvement of resident representatives. In turn, with the trust and common interest established among stakeholders, especially residents (Garnett and Cooper, 2014), probably gave feelings of ownership for the CTCP program (Wilson, 2015), and automatic Action Planning in the residents' households as a result. We suggest that both Action Planning and Stakeholder Engagement were crucial to mitigating the Inconvenience impact in E-6.

Distance is often implicated with Inconvenience, but it was not found to trend with performance here. In fact, the community with biggest increase had the largest distance to bins (E-6 in Table 1, Table 7). This is consistent with the large-scale systematic study of Distance which showed almost no effect on performance (Li et al., 2020).

4.2.2 Station Supervision

The second grounded theme whose trend was similar to changes in performance (bold in Table 7), was supervision and management of residents at the waste stations. Using trained assistants (volunteers and/or cleaners) is known to facilitate residents' behaviour change via determinants such as Prompt (Lin et al., 2016), Positive Interpersonal Interaction (Huang et al., 2018), Social norms (Dai et al., 2015), and Role Clarification (Xu et al., 2016).

From our on-site observations, a determinant we identified as a severe issue concerning Role Clarification in E-1, E-2 and E-4: some cleaners sort the waste from the bins in public view ('second sorting') or even take over (sort for residents) if they do not believe residents are capable of doing a good job. This could cause confusion for residents about their *Role and responsibility* in waste sorting (Xu et al., 2016), and possibly explain why they did become better sorters (reflected in decreased or unchanged effCR, CR_{FW} and Cont.L). In contrast, the cleaners of E-5 rarely sorted for the residents, but consistently persuaded residents that sorting was their responsibility, patiently educating residents on the operational details ("+" on Station Supervision). This could have contributed to the 7% improvement of effCR.

4.2.3 Cleaner's Attitude

Another grounded theme noted from on-site observations and interviews and found

to be loosely correlated to performance here, was the attitude presentation of the cleaner – who often acted as the recycling assistant which the residents met at the bins. Positive interpersonal interaction has been reported as a potentially key explanatory determinant of behaviour change for recycling performance (Huang et al., 2018; Lin et al., 2016). All of the assistants had been trained to present a Positive interaction, as even a neutral presentation was already known to undo benefits of Interpersonal Interaction (Huang et al., 2018). Positive cleaners (such as in E-6 or E-5 before CTCP launch) interacted actively with residents in terms of education and gentle persuasion. However, there are many reasons found in the field for cleaners not to be happy: the cleaner of E-1 reported emotional exhaustion from the harsh words of the HA manager; the cleaner of E-2 was outraged by unscheduled external inspections whose results directly affect monthly salary bonuses; and the E-5 cleaner’s attitude altered from enthusiastic to frustrated due when required to stay beside the waste station during the entire time period. Cleaners are typically the ones impacted, orally and/or financially, and this changes their attitude. At the least they might then resist communication, and passively sort for residents, ignoring all their training. Program implementers should perhaps be more aware of this issue, and its relevance to final performance.

4.2.4 Aggregated effects

We also considered whether the various small effects might somehow accumulate in a given community, and thus be correlated to performance. We explored this by crudely ‘summing’ the ratings, shown in the second-to-last line in Table 7. This coarse measure gave a potentially appropriate trend, and may be worth exploring in further studies. However, this would first require more careful normalisation of the ratings used, and better definitions of the themes, which would take several studies. A more efficient, alternative approach might be to instead work with their underlying determinants to try to produce a clear typology of standardised determinants, as in the series of studies outlined in the introduction.

4.3 Wider insights

This investigation is focussed on a specific research question - whether the CPCP program is effective or not – but, as in all studies using scientific method focussed on a research question, it is healthy to regularly check whether that research question is still the most useful one.

The results here indicate that this CTCP program did not improve performance. But actually, Shanghai communities already have what appears to be the highest Food Waste capture rates in the world (Li et al., 2017). A better question might be, what

recycling program got them there? Anecdotally, from studying hundreds of communities in Shanghai, we have noticed that the biggest jump in performance seems to come when bins are removed from each floor of apartments, and set up outside as central waste stations with several separate waste streams. We don't know why, and have not tested this hypothesis. But the data here is consistent: only E-6 had significant reductions in the number of waste stations (from 8 to 3) – and it was the only one with a jump in performance.

Thus, we propose the next study should focus on CP details as an isolated operational experimental factor, and at the same time explore qualitatively which determinants are thought to contribute.

4.4 Limitations of the study

Ideally the evaluation would have been of a random sample of communities *representing the city*, but we had to use the only cohort available at the time for data collection: 40 from only one district. Ideally we would have collected *all the waste for 24 hours* to ensure some resident types were not causing bias in the data, but we could not protect the data source in all the communities for 24 hours, so restricted collection to a broad window of 6:30-10:30 am. As the key characteristics of recycling performance in a community are not known well enough, it was not possible to determine what could comprise suitable 'control' communities, and thus we did not have any in this study. It was not possible to obtain accurate demographics data on the communities: this would have been useful for explore further factors.

5. Conclusions

The 'Certain Time, Certain Place' program in a district of Shanghai *did not improve* residential food waste sorting performance. An analysis of pre- and post-program performance showed no statistically significant changes in the measures of Effective Capture Rates, Contamination Levels, or Capture Rates (which was a proxy for participation rates) of the Food Waste. This result is important because the Shanghai CTCP program is being encouraged in other cities without confirmation evaluation, and it could be an unwise investment of time and finances.

The use of qualitative data collection has allowed grounded themes to emerge for future research consideration: time period arrangements; supervision style of waste stations; and attitude of the assistant cleaners. We were able to relate these to more precise, known, determinants of recycling of Inconvenience, Role Clarification, and Positive interactions, respectively. Action Planning and Stakeholder Engagement were

seen as potential mitigators of Inconvenience, whereas Distance was not. In effect, the mixed methods use of such qualitative data alongside quantitative performance data allows the elements of the CTCP program to be ‘deconstructed’ or linked to more established determinants of recycling performance that are slowly becoming standardised in the literature.

This is an important research contribution because the ‘science’ underlying successful recycling programs needs to be more visible to policy makers before they can make better science-based choices. This would be possible if such ‘deconstruction’ of policy elements into scientific factors were done more commonly.

For this CTCP program, the scientific perspective produced here is: that CT increases Inconvenience without giving any benefits from increasing supervision (which caused some negative attitudes). Whereas CP was not actually activated in this particular ‘CTCP Program’ except for one community – the only community where a stepwise improvement was seen. As such, no conclusion can be made about CP.

In conclusion, this study suggests that the ‘CTCP Program’ studied here would be more accurately described as ‘CT Program’, which has no clear advantages and many disadvantages. It is not clear here if CP is useful but it is possible, and worth studying further. The deconstruction of policy elements into scientific factors allows more clear considerations.

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References

- Abrahamse, W., Steg, L., 2013. Social influence approaches to encourage resource conservation: A meta-analysis. *Global Environmental Change* 23. <https://doi.org/10.1016/j.gloenvcha.2013.07.029>
- Babbie, E.R., 2010. *The Practice of Social Research* - Earl R. Babbie - Google Kitaplar [WWW Document]. Cengage Learning. <https://doi.org/9780495598411>
- Barr, S., Ford, N.J., Gilg, A.W., 2003. Attitudes towards recycling household waste in Exeter, Devon: quantitative and qualitative approaches. *Local Environment* 8. <https://doi.org/10.1080/13549830306667>
- Barr, S., Gilg, A.W., 2005. Conceptualising and analysing household attitudes and actions to a growing environmental problem. Development and application of a framework to guide local waste policy. *Applied Geography* 25. <https://doi.org/10.1016/j.apgeog.2005.03.007>
- Barr, S., Gilg, A.W., Ford, N.J., 2001. Differences between household waste reduction, reuse and recycling behaviour: A study of reported behaviours, intentions and explanatory variables. *Environmental and Waste Management* 4.

- Bian, S., Nduneseokwu, C.K., Li, C., Harder, M.K., 2021. Drift in policy implementation: Incentives thwarted in a recycling programme. *Waste Management & Research: The Journal for a Sustainable Circular Economy*. <https://doi.org/10.1177/0734242x211025193>
- Carlson, A.E., 2001. Recycling Norms. *California Law Review*. <https://doi.org/10.2307/3481159>
- Chang, Y.M., Liu, C.C., Dai, W.C., Hu, A., Tseng, C.H., Chou, C.M., 2013. Municipal solid waste management for total resource recycling: A case study on Haulien County in Taiwan. *Waste Management and Research* 31, 87–97. <https://doi.org/10.1177/0734242X12465458>
- Chao, Y.L., 2008. Time series analysis of the effects of refuse collection on recycling: Taiwan's "Keep Trash Off the Ground" measure. *Waste Management* 28. <https://doi.org/10.1016/j.wasman.2007.02.012>
- Chen, W., 2020. 垃圾分类各地各有招 (Different places have their own ways to sort garbage). *Environmental Economy* 40–42.
- Christensen, C.M., Carlile, P.R., 2009. Course research: Using the case method to build and teach management theory, in: *Academy of Management Learning and Education*. <https://doi.org/10.5465/AMLE.2009.41788846>
- Dahlén, L., 2005. To Evaluate Source Sorting Programs in Household Waste Collection Systems. *luleå tekniska universitet* 83.
- Dahlén, L., Vukicevic, S., Meijer, J.E., Lagerkvist, A., 2007. Comparison of different collection systems for sorted household waste in Sweden. *Waste Management* 27. <https://doi.org/10.1016/j.wasman.2006.06.016>
- Dai, Y.C., Gordon, M.P.R., Ye, J.Y., Xu, D.Y., Lin, Z.Y., Robinson, N.K.L., Woodard, R., Harder, M.K., 2015. Why doorstepping can increase household waste recycling. *Resources, Conservation and Recycling* 102, 9–19. <https://doi.org/10.1016/j.resconrec.2015.06.004>
- Dai, Y.C., Lin, Z.Y., Li, C.J., Xu, D.Y., Huang, W.F., Harder, M.K., 2016. Information strategy failure: personal interaction success, in urban residential food waste segregation. *Journal of Cleaner Production* 134, 298–309. <https://doi.org/10.1016/j.jclepro.2015.12.104>
- Eppel, S., Sharp, V., Daviesa, L., 2013. A review of Defra's approach to building an evidence base for influencing sustainable behaviour. *Resources, Conservation and Recycling* 79. <https://doi.org/10.1016/j.resconrec.2013.06.001>
- Evasdottir, E.E.S., 2007. Obedient autonomy: Chinese intellectuals and the achievement of orderly life, *Obedient Autonomy: Chinese Intellectuals and the Achievement of Orderly Life*. <https://doi.org/10.5860/choice.42-1653>
- Garcés, C., Lafuente, A., Pedraja, M., Rivera, P., 2002. Urban waste recycling behavior: Antecedents of participation in a selective collection program. *Environmental Management* 30. <https://doi.org/10.1007/s00267-002-2601-2>
- Garnett, K., Cooper, T., 2014. Effective dialogue: Enhanced public engagement as a legitimising tool for municipal waste management decision-making. *Waste Management* 34. <https://doi.org/10.1016/j.wasman.2014.08.011>
- González-Torre, P.L., Adenso-Díaz, B., 2005. Influence of distance on the motivation

- and frequency of household recycling. *Waste Management* 25.
<https://doi.org/10.1016/j.wasman.2004.08.007>
- Guo, Y., 2016. 广州生活垃圾定时定点分类投放模式探析 (Analysis on the mode of Certain Time Certain Place household waste classification and deposit in Guangzhou). *Urban Management and Science & Technology* 18, 61–63.
<https://doi.org/10.16242/j.cnki.umst.2016.03.015>
- Hage, O., Söderholm, P., Berglund, C., 2009. Norms and economic motivation in household recycling: Empirical evidence from Sweden. *Resources, Conservation and Recycling* 53. <https://doi.org/10.1016/j.resconrec.2008.11.003>
- Huang, Y.Y., Tamas, P.A., Harder, M.K., 2018. Information with a smile – Does it increase recycling? *Journal of Cleaner Production* 178, 947–953.
<https://doi.org/10.1016/j.jclepro.2018.01.006>
- Intergovernmental Panel on Climate Change, 2014. *Climate Change 2014 Mitigation of Climate Change, Climate Change 2014 Mitigation of Climate Change*.
<https://doi.org/10.1017/cbo9781107415416>
- Joseph, K., 2006. Stakeholder participation for sustainable waste management. *Habitat International* 30, 863–871.
<https://doi.org/10.1016/j.habitatint.2005.09.009>
- Kaplan Mintz, K., Henn, L., Park, J., Kurman, J., 2019. What predicts household waste management behaviors? Culture and type of behavior as moderators. *Resources, Conservation and Recycling* 145.
<https://doi.org/10.1016/j.resconrec.2019.01.045>
- Knickmeyer, D., 2020. Social factors influencing household waste separation: A literature review on good practices to improve the recycling performance of urban areas. *Journal of Cleaner Production*.
<https://doi.org/10.1016/j.jclepro.2019.118605>
- Li, C., Huang, Y., Harder, M.K., 2017. Incentives for food waste diversion: Exploration of a long term successful Chinese city residential scheme. *Journal of Cleaner Production* 156, 491–499. <https://doi.org/10.1016/j.jclepro.2017.03.198>
- Li, C., Wang, Y., Li, Y., Huang, Y., Harder, M.K., 2021. The incentives may not be the incentive: A field experiment in recycling of residential food waste. *Resources, Conservation and Recycling* 168.
<https://doi.org/10.1016/j.resconrec.2020.105316>
- Li, C., Zhang, Y., Nouvellet, P., Okoro, J.O., Xiao, W., Harder, M.K., 2020. Distance is a barrier to recycling – or is it? Surprises from a clean test. *Waste Management* 108, 183–188. <https://doi.org/10.1016/j.wasman.2020.04.022>
- Li, M., Zhou, W., 2019. 生活垃圾定时定点分类投放模式探析——以广州市花都区紫光园小区为例 (Analysis on the Mode of Certain Time Certain Place Classification of Household Waste--A case Study of Ziguang Garden Community, Huadu District, Guangzhou City). *Urban Management and Science & Technology* 21, 63–65. <https://doi.org/10.16242/j.cnki.umst.2019.01.017>
- Li, X., 2017. 看台湾如何有效实现垃圾分类回收 (How is waste classification and recycling effectively achieved in Taiwan) [WWW Document]. *Xinhuanet*. URL http://www.xinhuanet.com/tw/2017-03/10/c_129506408.htm (accessed 7.7.21).

- Lin, Z.Y., Wang, X., Li, C.J., Gordon, M.P.R., Harder, M.K., 2016. Visual prompts or volunteer models: An experiment in recycling. *Sustainability (Switzerland)* 8, 458. <https://doi.org/10.3390/su8050458>
- Lu, L.T., Hsiao, T.Y., Shang, N.C., Yu, Y.H., Ma, H.W., 2006. MSW management for waste minimization in Taiwan: The last two decades. *Waste Management* 26. <https://doi.org/10.1016/j.wasman.2005.10.005>
- Midgley, L., Olson, M., 1969. The Logic of Collective Action: Public Goods and the Theory of Groups. *The Western Political Quarterly* 22. <https://doi.org/10.2307/446187>
- Perrin, D., Barton, J., 2001. Issues associated with transforming household attitudes and opinions into materials recovery: A review of two kerbside recycling schemes. *Resources, Conservation and Recycling* 33. [https://doi.org/10.1016/S0921-3449\(01\)00075-1](https://doi.org/10.1016/S0921-3449(01)00075-1)
- Refsgaard, K., Magnussen, K., 2009. Household behaviour and attitudes with respect to recycling food waste - experiences from focus groups. *Journal of Environmental Management* 90. <https://doi.org/10.1016/j.jenvman.2008.01.018>
- Rousta, K., Bolton, K., Dahlén, L., 2016. A procedure to transform recycling behavior for source separation of household waste. *Recycling* 1. <https://doi.org/10.3390/recycling1010147>
- Rousta, K., Bolton, K., Lundin, M., Dahlén, L., 2015. Quantitative assessment of distance to collection point and improved sorting information on source separation of household waste. *Waste Management* 40. <https://doi.org/10.1016/j.wasman.2015.03.005>
- SCAB, SLCAAB, 2019. Guidance on How to Play the Role of Community Governance and Social Organization in the City to Promote the Classification of Household Waste. Shanghai.
- Shen, X., Chen, B., Du, H., 2020. 上海市垃圾分类经验以及对长三角地区的启示 (Waste classification experience in Shanghai and the inspiration to the Yangtze River Delta). *Recyclable Resources and Circular Economy* 13, 19–22.
- SLCAAB, 2019. Guidelines for Shanghai Municipality to Implement Certain Time Certain Place Classifying and Depositing System of Domestic Waste. Shanghai.
- Song, Y., 2019. 上海市生活垃圾管理的启示 (The enlightenment of Shanghai municipal solid waste management). *Academic Search for Truth and Reality* 86–90. <https://doi.org/10.13996/j.cnki.taqu.2019.06.013>
- Sustainable Behaviour Research Group, 2020. A Casebook of Globalcities' Community Waste Sorting.
- Tian, H., 2015. The evolution and future trend of China's MSW management policy. *Urban Problems* 82–89.
- Tonglet, M., Phillips, P.S., Bates, M.P., 2004. Determining the drivers for householder pro-environmental behaviour: Waste minimisation compared to recycling. *Resources, Conservation and Recycling* 42, 27–48. <https://doi.org/10.1016/j.resconrec.2004.02.001>
- Tucker, P., Grayson, J., Speirs, D., 2001. Integrated effects of a reduction in collection frequency for a kerbside newspaper recycling scheme. *Resources, Conservation*

- and Recycling 31. [https://doi.org/10.1016/S0921-3449\(00\)00078-1](https://doi.org/10.1016/S0921-3449(00)00078-1)
- Wang, R., 2019. 论城市生活垃圾分类的公众行为引导机制 (Discussing the public behavior guidance mechanism of municipal solid waste classification). *China Collective Economy* 1–3.
- Wang, X., Guan, W., 2021. 城市小区生活垃圾分类运营模式探究 (Study on Operation Mode of Domestic Waste Classification in Urban Community). *Energy Conservation & Environmental Protection* 38–39. <https://doi.org/10.13996/j.cnki.taqu.2019.06.013>
- Wei, C., 2020. 上海社区垃圾分类的经验对广州市的启示 (The experience of Shanghai community garbage classification and its enlightenment to Guangzhou). *Resources Economization & Environmental Protection* 118–119. <https://doi.org/10.16317/j.cnki.12-1377/x.2020.10.057>
- Wilson, D.C., 2015. *Global Waste Management Outlook*.
- Xi, H., 2020. 上海市生活垃圾全程分类体系建设现状分析及对策建议 (Analysis on the Construction Status and Countermeasures and Suggestion of Whole-process Classification System of MSW in Shanghai). *Environmental Sanitation Engineering* 28, 80–85. <https://doi.org/10.19841/j.cnki.hjwsgc.2020.03.015>
- Xu, D.Y., Lin, Z.Y., Gordon, M.P.R., Robinson, N.K.L., Harder, M.K., 2016. Perceived key elements of a successful residential food waste sorting program in urban apartments: stakeholder views. *Journal of Cleaner Production* 134, 362–370. <https://doi.org/10.1016/j.jclepro.2015.12.107>
- Yang, Y., 2016. 习近平的政策观 (The Policy View of President Xi Jinping) [WWW Document]. *China Plus*. URL <http://news.cri.cn/20160531/10ab7459-62a8-16d0-7fc2-52eecake20ae.html> (accessed 7.6.21).

Supplementary Information

Appendix I

Table of list of stakeholder interview questions

No.	Interview questions ^a
Residents	
1	Do you know that CTCP in your community is about to start? How do you find out? Do you know when and where?
2	How will CTCP be implemented? Will the station be locked after CT (will the temporary points be removed)? Are there miss-time bins?
3	Is there any rule in the community that reward residents for doing well in WS? Any measure taken for those who did a bad job?
4	How do you sort your waste at home?
5	When do you usually throw your waste (Fixed time/flexible)?
6	Do you feel that CTCP might cause inconvenience for you? Was it the time or the place? Why?
7	Do you think you need to be reminded of CTCP? How?
8	Any experience with deposit waste after CT? Describe what happened?
9	Do you think you will adapt to CTCP? Will the implementation of CTCP change your WS behaviour or lifestyle?
10	What other impacts CTCP might have on you? On your community?
11	What is the attitude of people around you (family members)?
12	What do you think the WS situation with other residents?
13	Did it happen before that the cleaner/volunteers help you to sort directly?
14	What have CC, HA, and RA done before CTCP?
15	In general, what is your attitude towards CTCP?
16	Is it worth promoting? Why? And idea or suggestion you want to add?
Cleaner	
1	How many cleaners are there in your community? How many households are served by one cleaner? Who is in charge?
2	What's the overall WS participation/WS performance with this community?
3	Performance of dry/wet separation? 1st sorting? 2nd?
4	Do you know that CTCP in your community is about to start? How do you find out? Do you know when and where?
5	How will CTCP be implemented? Will the station be locked after CT (will the temporary points be removed)? Are there miss-time bins?
6	What has this community done before CTCP?

- 7 What your main job in WS? What community requires you to do in CTCP
- 8 Do you worry about CTCP might affect you daily work?
- 9 Do you need to do a 2nd sorting? When?
- 10 Do you know residents here well?
- 11 How do you normally deal with the people who litter or mix their waste? Do you remind them or help them directly when they throw their waste?
- 12 Do you think CTCP will help/hinder residents forming WS habits? why
- 13 What is your attitude towards CTCP?

Volunteer

- 1 How many volunteers here? At each dumping point? Or go on patrol?
- 2 What's the overall WS participation/WS performance with this community?
- 3 Do you know that CTCP in your community is about to start? How do you find out? Do you know when and where?
- 4 How will CTCP be implemented? Will the station be locked after CT (will the temporary points be removed)? Are there miss-time bins?
- 5 What has this community done before CTCP?
- 6 What your main job in WS? What community requires you to do in CTCP
- 7 Do you worry about CTCP might affect you daily work?
- 8 Do you know residents here well?
- 9 How do you normally deal with the people who litter or mix their waste? Do you remind them or help them directly when they throw their waste?
- 10 Do you think CTCP will help/hinder residents forming WS habits? Why?
- 11 What is your attitude towards CTCP?

Community Administrations (community committee, housing association and residential association)

- 1 How many households are here? Percentage of elderly (physically inconvenienced, nanny)? Workers? Renter? Communist Party members? How many volunteer? Cleaners? Pattern of residents' lifestyle?
- 2 Do you know residents here well? Is the communication process smooth in other community works?
- 3 What's the overall WS participation/WS performance with this community?
- 4 Why introduce CTCP to your community?
- 5 What publicity work have you done to promote CTCP? Coverage? In which way?
- 6 Any particular measures planned to take to remind residents of CTCP? Doorstepping, pledge, sign, camera...

- 7 How will CTCP be implemented? Will the station be locked after CT (will the temporary points be removed)? Are there miss-time bins?
 - 8 Did you solicit residents' opinions on the timing and location (convenience)? How current CT and CP were decided? Was there a strong reaction from the residents in the solicitation process?
 - 9 Many communities report littering after CT, how do you plan to address this part of the problem?
 - 10 For those who littering, how will you supervise? Will you keep tracking? Any measures?
 - 11 Is there a reward or punishment system for residents' performance of CTCP participation?
 - 12 How will cleaners/volunteers' work be arranged in CTCP?
 - 13 What will be your main job in CTCP?
 - 14 How is the work distributed among the other parties?
 - 15 Do you think CTCP will help/hinder residents forming WS habits? why
 - 16 What is your attitude towards CTCP?
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^a Actual interviews were conducted in Chinese, and time tense-sensitive for pre- and post- 'Equilibrium' state. Interview questions were tailored for experimental group and control group

Appendix II

Extended evidence for Table 5

Grounded Themes	Rating	Researchers reasoning	Evidence
Time Arrangements	‘-’	Inconvenient for many residents. Residents emphasized the inconvenience and also that management refused to make any changes	<p>1. On-site observation: See time periods arrangement from Table 1.</p> <p>2. Resident interview: <i>“...my workplace is quite far from here, so I have to leave early. But the station won’t open until 7:00 am...”</i> <i>“...I am a ‘996’ worker (9am-9pm, 6 days/week), I come home late and I’d like to sleep late next morning, so I always miss the CT and have to store my waste for many days...”</i></p> <p>3. HA interview: <i>“...we will not change the time set. As you probably know, even if we opened the station at 6 in the morning, there still would be residents come before that. So it is better we force them to follow our schedule and form the good habit...”</i></p>
Waste Station Coverage of Compound	‘0’	There is only one waste station in the central area of E-1 community	1. On-site observation: No change during CTCP implementation.
Waste Station Upgrades	‘0’	There was a reconstruction in 2019, before the launch the new waste law. The station gate was re-painted, and lights and hand washing sink were installed.	1. On-site observation: No change during CTCP implementation.

		It had not been changed since then	
Serious Launch	‘+’	It possesses factors perceived by residents to lower conflict of CTCP launch, involving serious door-stepping, obvious publicity materials, designated activities, big coverage, etc.	<p>1. CC interview: <i>“...before the CTCP launch, we arranged many activities, such as broadcasting with loudspeaker, door-stepping, hanging banner, etc....door-stepping covered at least 80 % of all households, and now all of them (residents) should have known it...”</i></p> <p>2. On-site observation: During the first a couple of days of CTCP launch, community CC hanged a loudspeaker by their waste station. It played waste deposit related regulations over and over. In addition, CC leader, HA manager and resident volunteers had stayed by the station all day for 2 weeks.</p> <p>3. Resident interview: <i>“...Yes, I know CTCP is about to launch, CC and volunteers came to my door the other day...”</i> <i>“...of course I know...well, I learnt about that by the notice sticking on our building entrance. I believe everyone can see it, you cannot miss it...”</i></p>
Flexibility of Administration	‘-’	CC and HA ignores residents’ complaints and ran CTCP really strictly	<p>1. Resident interview: <i>“...we have already sort our waste, why can’t we deposit it at any time. Or maybe they can just add a few hours...”</i> <i>“...certainly we have filed complaint about inconvenient timing to the CC’s office, but we have been told that this is the decision of upper level government, which they cannot overrule...I think this is just ‘sloth administration’ (prevaricate with excuses)...”</i></p>

Station Supervision	‘-’ No interaction with residents who litter waste after CT or sort for residents are believed no helping for behaviour change of residents	<p>1. On-site observation:</p> <p>The cleaner looked exhausted and listlessly did her/his work. When residents came down late and left waste bags by the station, the cleaner just picked it up and stored in a small room next-door (waste station is not allowed to be opened during non-CT).</p> <p>Within CTs, if residents handed over their waste to cleaner, the cleaner would always take over and sort for them</p>
Cleaner’s Attitude	‘-’ Every time we went to E-1 community, the cleaner complains about her/his unjust situation to us	<p>1. Cleaner interview:</p> <p><i>“...the HA manager yells at me every day, every time when I was trying to help resident, the words he used are unspeakable, I hate him...”</i></p> <p>2. On-site observation:</p> <p><i>“Go to hell!”</i> mumbling by the cleaner, right after their HA manager lectured the cleaner with a very strong tone.</p> <p>There were even a gathering of residents express their sympathy towards their cleaner and anger towards that HA manager.</p> <p>3. Resident interview:</p> <p><i>“...our cleaner is so pathetic. She works really hard since always. Will you look at her now? She is actually younger than me, but look at the wrinkles on her face, and her humpback...our HA is so over the line...I am now sorting my waste only for the sake of our cleaner...”</i></p> <p><i>“...I don’t get it, why the HA manager treat our cleaner like that. She/he is doing a great job, and she/he deserves better...”</i></p>
Adaptability of Residents	‘-’ The issue of littering is very obvious	<p>1. On-site observation:</p> <p>Many residents litter waste bags by the bins during non-CT instead of changing</p>

their schedules to the CT.

Gathering of residents complain about CTCP.

Deposit Density (related to lifts)	'0'	6-floor building (Table 1) with relatively low density of households	1. On-site observation: No obvious change during CTCP implementation.
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