

Precycling as a self-experiment. An intervention study on packaging waste prevention in private households (HomeLabs)

Preliminary results

27th February 2023

Elisabeth Süßbauer
Klara Wenzel
Justus Caspers
Rabea-Lorina Dehning
Nathalie Korf
Cassiopea Staudacher
Sarah Julie Otto



The project "PuR – Precycling as a Means of Resource Efficiency. Systemic Solutions of Packaging Prevention" is a cooperation between the Technische Universität Berlin and the Wuppertal Institute for Climate, Environment, Energy gGmbH. The junior research group PuR is funded on behalf of the German Federal Ministry of Education and Research (BMBF) as part of the Research for Sustainable Development (FONA) framework program.

This report is a translation of the original German report titled "Precycling im Selbstversuch. Eine Interventions-Studie zu Verpackungsabfallvermeidung in privaten Haushalten", published in July 2022. The translation has been reviewed and approved to ensure accuracy and consistency with the original version. The responsibility for the content of this publication lies with the authors.

Please quote the report as follows:

Süßbauer, Elisabeth; Wenzel, Klara; Caspers, Justus; Dehning, Rabea-Lorina; Korf, Nathalie; Staudacher, Cassiopea; Otto, Sarah Julie (2023): Precycling as a self-experiment. An intervention study on packaging waste prevention in private households (HomeLabs). Preliminary results. Center for Technology and Society, TU Berlin. <https://pur-precycling.de/wp-content/uploads/2023/03/Ergebnisbericht-PuR-HomeLabsEN.pdf>

Project duration: May 2019 – April 2024

Project coordination/ contact person:

Dr. Elisabeth Süßbauer
Center for Technology and Society
Technical University Berlin
Kaiserin-Augusta-Allee 104
10553 Berlin
suessbauer@ztg.tu-berlin.de
Tel. +49-30-314-29822

Members of the junior research group:

Dr. Elisabeth Süßbauer (TU Berlin)
Dr. Henning Wilts (Wuppertal Institute)
Justus Caspers, M.Sc. (TU Berlin)
Rabea-Lorina Dehning, M.A. (TU Berlin)
Sarah Julie Otto, M.Sc. (TU Berlin)
Jennifer Schinkel, M.A. (Wuppertal Institute)
Klara Wenzel, M.Sc. (TU Berlin)

This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License. The license is available at <http://creativecommons.org/licenses/by-nc-nd/4.0>



Table of Contents

List of Figures and Tables.....	1
1. Background and aim of the study – Why is precycling important?.....	3
2. Building the HomeLabs – What happened when?	4
2.1 Recruitment of participants.....	4
2.2 Timing and interventions.....	5
2.3 Grouping	5
2.4 Methods of data collection.....	6
3. Participants – Who has participated in the HomeLabs?.....	10
4. Key findings – Precycling in everyday life	11
4.1 Change of precycling behavior	11
4.2 Change in reuse behavior	14
4.3 Change in the quantity of domestic (packaging) waste	18
4.4 Change of separation behavior	21
5. Conclusions – What have we learned?.....	24
5.1 Central findings.....	24
5.2 Implications for practice and policy.....	25
5.3 Limitations and further research needs	26
6. Sources.....	28

List of Figures and Tables

Table 1: Intervention formats according to groups.....	6
Table 2: Data collection methods by groups	6
Figure 1: HomeLabs Flyer	4
Figure 2: Example of a completed packaging diary	8
Figure 3: Waste sorting in the Department of Circular Economy and Recycling Technology at TU Berlin	9
Figure 4: Timeline of the HomeLabs activities.....	10
Figure 5: Average precycling behavior over the course of the HomeLabs.....	11
Figure 6: Example of a mind map on packaging waste prevention.....	13
Figure 7: Average behavior in group 2 over the course of the HomeLabs.....	14
Figure 8: Storage of reusable containers in the household.....	15
Figure 9: Experiences with the use of reusable containers.....	16
Figure 10: Experiences with shopping in a zero-waste store documented in the workbook	17
Figure 11: Total waste mass and mass of all four waste fractions for week 0 and week 5 in comparison to the average for Berlin	18
Figure 12: Number of packaging items.....	19
Figure 13: Share of packaging materials.....	21
Figure 14: Share of packaging within the four waste fractions for week 0 and week 5. The percentages represent the mass share	22
Figure 15: Disposal routes of packaging	23

Summary

Packaging waste pollutes public spaces and contributes to climate change. In particular, the disposal of waste is associated with high resource and energy consumption. This problem can only be partially solved by recycling technologies because the material often loses quality during recycling and a certain proportion is even lost. Avoiding packaging waste is therefore the ultimate goal of the waste hierarchy. The best waste is the waste that never happens. This is the essence of precycling, which means reducing waste before it is generated.

But how can packaging be avoided in everyday life? This question was investigated very practically in the PuR HomeLab study. HomeLabs are a form of living labs in which research does not take place in public spaces but in private households. People's homes are the place where a large proportion of packaging is used and disposed of and where it is integrated into everyday routines. By experimenting with new behaviors and involving participants in the research, HomeLabs can be used to explore the conditions for changing consumption practices.

Together with around 100 households in Berlin, the project investigated between May and November 2021 how different interventions affect the quantity and composition of household packaging waste. The participants documented their packaging waste, gave each other tips, exchanged experiences, took part in webinars, and were given tasks to try out reusable containers. The research team was supported by our practice partners an environmental NGO ([BUND](#)), an association for tap water ([atip:tap e.V.](#)), a zero waste store ([kathi&käthe fairverpackt](#)), and a business for reusable take-away food containers ([reCIRCLE](#)), who provided materials for the HomeLabs and organized various webinars on the topic of precycling.

Preliminary results show that, on average, participants reported more precycling behavior immediately after the intervention phase than before, regardless of the intervention group. The increase in precycling behavior also seems to have had a positive impact on the actual amounts of waste produced by households during the study period since the amount of packaging waste decreased slightly after the intervention phase. However, long-term changes in behavior seem to occur only among participants who received a specific intervention on reuse. This intervention not only provided the participants with knowledge but combined material incentives with tasks for experimentation in everyday life and social exchange. Implications for practice and policy are formulated based on these preliminary findings.

You can find more information about the project, as well as information and tips on how to avoid packaging in everyday life, [on our website](#).

1. Background and aim of the study – Why is precycling important?

Germany is the European champion! At least when it comes to packaging waste. In 2019, the sad peak value of 18.9 million tons was reached, and the trend is rising (Burger et al. 2021). The consequences of this are not only the pollution of public space but also effects on climate change. The disposal of waste is particularly associated with high resource and energy consumption. This problem can only be partially solved by recycling technologies because the material often loses quality during recycling and a certain proportion is even lost.

Waste prevention therefore is the primary objective of the waste hierarchy (European Parliament 2018). Before waste is recycled or incinerated, the first step is to check whether waste cannot be avoided from the outset. So, it's all about the before, the *precycling*. After all, the best waste is the waste that never happens. But how to reduce single-use packaging in everyday life? This question was investigated as part of an intervention study in German households (HomeLabs). HomeLabs are a form of living labs in which the research does not take place in public spaces, but in private households. By experimenting with new behaviors and involving participants in the research, HomeLabs can be used to explore the conditions for changing consumption practices. The method has proven successful in researching other consumption fields such as energy saving or sustainable nutrition (e.g., Devaney and Davies 2017). To implement HomeLabs on precycling, the PuR team worked closely with approximately 100 Berlin households and thus gained insights into the obstacles and potentials of everyday packaging avoidance. The perspective on everyday domestic life is central, as approximately half of the packaging waste in Germany is generated in private households (Burger et al. 2021). The idea of the research study was to focus on the place where packaging is used and disposed of and where it is integrated into most of everyday food routines: the home.

The study had two objectives: *Firstly*, to find out to what extent the participants already implement precycling in their everyday lives and what quantities and types of waste are generated in the households. By domestic precycling behavior, we mean different behaviors and strategies of consumers that contribute to reducing or completely avoiding packaging waste for food products (e.g., buying fruit and vegetables in bulk). This also includes the use of reusable containers such as cans or bottles for (prepared) food and beverages, which we call reuse behavior. Reuse behavior refers to the way reusable containers and reusable packaging for food are handled in everyday life, e.g., how they are stored, cleaned, or transported and what they are used for. Furthermore, we also include the correct separation and sorting of packaging waste under precycling, as this facilitates recycling in the plants, which can save energy and resources.

The *second objective* was to investigate how precycling can be promoted in the household within a defined period. For this purpose, the participants were randomly divided into three different groups at the beginning of the study: two experimental groups and one control group. These groups participated in different interventions (webinars, a web platform, and others) partly with each other, but also separately. The impact of the interventions was measured by examining the extent to which waste quantity and composition, (self-reported) precycling behavior and reuse behavior changed. To gain a comprehensive understanding of domestic precycling behavior, both the self-perceived change in behavior and the number and quantity of packaging waste generated by the households was captured and analyzed. For this, we used, on the one hand, packaging diaries that were completed by HomeLab participants themselves. On the other hand, the research team collected and analyzed the households' waste itself. To conduct this mix of methods, researchers from the social sciences as well as from engineering sciences at TU Berlin worked together.

The HomeLab study contributes to a better understanding of the role of consumers in precycling. Overall, however, the topic of packaging avoidance is complex and requires many preconditions and can ultimately only be successfully implemented through the joint participation of industry, trade, politics, and civil society. With this in mind, the goal of the PuR project is to examine precycling from various perspectives and with a view to the different life phases of products and, building on this, to test and implement systemic solutions for promoting precycling together with practice partners.

2. Building the HomeLabs – What happened when?

2.1 Recruitment of participants

Participants were recruited in cooperation with BUND Berlin, a large German environmental association. The calls for participation were announced between October 2020 and February 2021 at various outdoor events organized by BUND on the topic of resource conservation (e.g., events, where people could trade household items) as well as via various online mailing lists, social media, and websites (e.g., Twitter account of the Technische Universität Berlin, a mailing list of BUND Berlin, neighborhood offices in Berlin, and the German neighborhood online platform nebenan.de). Through these channels, we distributed a flyer with the headline "Participate in the experiment and become a precycling household! Berliners get active for packaging prevention". The flyer contained some key information about the project such as the expected time frame of the study, an outlook on the process and methods, as well as a link and a QR code for registration (see Figure 1). Those interested were invited to sign up along with their entire household. Households that participated for the entire duration of the study received an incentive of 50 to 100 euros.

Precycling-HomeLabs 2021

Machen Sie den Selbstversuch und werden Sie ein Precycling-Haushalt!
Berliner*innen werden aktiv für Verpackungsvermeidung

Wer kann mitmachen?
Wir suchen aufgeschlossene Menschen, die in Berlin leben, Lust haben, den Müll in eigenen Haushalt und in der eigenen Nachbarschaft zu reduzieren. Aus allen Anmeldungen wählen wir dann die Pilot Haushalte aus.

Was sind HomeLabs?
Die PuR-HomeLabs sind ein Kooperationsprojekt zwischen der Forschungsgruppe PuR und der Abfallberatung des BUND Berlin. HomeLabs sind eine wissenschaftliche Methode, bei der die Forschung nicht klassisch im Labor stattfindet, sondern im Alltag der Menschen. Genauer gesagt: bei Ihnen zu Hause.

Das heißt, Sie werden selbst zum aktiven Teil des Forschungsteams: Sie erheben Daten zu Hause in Ihrem Alltag (z.B. in Form von Fragebögen, Tagebüchern oder Fotos) und experimentieren mit Verpackungsalternativen.

Was erwartet Sie?
Zusammen mit anderen Haushalten experimentieren Sie zu Hause ca. sechs Wochen lang zum Thema Verpackungsvermeidung:
 ♦ Kennenlernen und Erproben von Precycling
 ♦ Möglichkeiten und Verpackungsalternativen im Alltag
 ♦ Teilnahme an Alltags-Challenges
 ♦ Dokumentation Ihrer Erfahrungen zu unterschiedlichen Zeitpunkten anhand von Forschungstagebüchern und Fotos
 ♦ Teilnahme an einer Befragung und einem Interview jeweils zu Beginn und am Ende der HomeLabs sowie im Rahmen einer Abschlussbefragung teil
 ♦ Austausch mit anderen – hierfür stellen wir eine virtuelle Plattform zur Verfügung

Ihre Vorteile
 ✓ Ihr persönlicher Beitrag zum Umwelt- und Ressourcenschutz & zur sozial-ökologischen Forschung
 ✓ Kostenlose Beratungsangebote und Veranstaltungen zum Thema Precycling
 ✓ Kostenloses „Precycling Starterkit“ mit Infos und Materialien zum Thema Precycling
 ✓ Persönliche Auswertung und Rückmeldung zu den Alltags-Challenges
 ✓ Jeder Precycling-Haushalt erhält eine Aufwandsentschädigung von 50 - 100€

Haben wir Ihr Interesse geweckt?
Sie können sich mit diesem Formular direkt für die Teilnahme an unseren HomeLabs bewerben:
<https://pur-precycling.de/home-labs/>

Wenn Sie noch Fragen an uns haben, dann schreiben Sie uns gerne.

Klara Wenzel, M.Sc.
Ansprechpartnerin HomeLabs

Zentrum Technik und Gesellschaft, TU Berlin
Kaiserin-Augusta-Allee 104, 10553 Berlin
+49 (0)30 314-29813
wenzel@ztg.tu-berlin.de

Timeline:
 2020
Okt. 2020: Bewerbungphase
 2021
Jan. 2021: Auswahl der Haushalte
 Febr. 2021: Start der HomeLabs (Dauer 6-8 Wochen)
 Apr. 2021: Ende der HomeLabs
 Mai 2021: Abschlussbefragung
 Okt. 2021: Abschlussbefragung

Alle Termine werden mit den Teilnehmer*innen abgestimmt. Änderungen und Ergänzungen sind vorbehalten.

Partner:
 Bundesministerium für Bildung und Forschung
 FONA
 Wuppertal Institut
 BUND
 PuR

Figure 1: HomeLabs Flyer

2.2 Timing and interventions

The main phase of the Precycling HomeLabs started on May 10, 2021, with a kick-off event and lasted until June 6, 2021. During this period of six weeks, different interventions targeting precycling behavior took place. By comparing the different intervention formats, the aim was to explore which measures impacted the self-reported and waste generation measured by the research team in the households. The individual intervention formats are presented below. Since there were various restrictions on face-to-face gatherings at events at the time due to the Corona pandemic, all formats took place digitally.

- **Kick-off event:** To officially launch the HomeLabs, an approximately one-hour introductory event took place via Zoom, during which the research team introduced itself and presented the study concept to the participants. The participants had the opportunity to ask questions.
- **Webinars:** The intervention phase consisted of four webinars, one per week, in which different aspects of packaging waste prevention were presented and discussed with the participants.
 - Week 1: **Packaging avoidance in everyday life**, carried out by representatives of BUND Berlin
 - Week 2: **Tap water**, carried out by representatives of the association a tip:tap e.V.
 - Week 3: **Zero-waste shopping**, carried out by the owners of the zero-waste store kathi&käthe
 - Week 4: **Waste separating and recycling**, conducted by representatives of BUND Berlin
- **Web Forum:** During the intervention phase, participants could access the web forum, a restricted area on the research project website where materials related to the webinars were provided and where participants could exchange ideas or ask questions to the team.
- **Precycling Starter Kit & Workbook:** At the beginning of the HomeLabs, a package was sent to participating households containing information on precycling, two reusable bowls and cutlery from reCIRCLE, and a workbook. The workbook encouraged people to try out and reflect on packaging avoidance and reuse in everyday life and to get into conversations with other household members. To this end, the workbook contained various exercises, including conducting a short interview on precycling with a person from one's own environment or filling out a mind map. In line with the topics of the webinars, the workbook also contained practical tasks, e.g., taking the reusable bowls to favorite restaurants or trying out a zero-waste store. The participants documented their experiences as short texts, drawings and in the form of photos.
- **Group discussion:** At the end of the intervention phase, guided discussions took place in small groups where participants shared their experiences during the HomeLabs with each other.
- **FAQ:** In week 6, participants received an overview document of the most frequently asked questions by participants and the according answers by the research team.

To measure whether changes in precycling behavior are persistent over time, a follow-up survey was conducted from October 25 to November 7, 2021.

2.3 Grouping

At the beginning of the study, all participating households were randomly divided into three different experimental groups. In these three groups, participants engaged in different intervention formats. The assignment to these different groups allowed for comparing the effects of the interventions described above. The goal of the HomeLabs was to investigate whether and how precycling behavior and packaging waste levels in households changed during the study and which interventions were particularly effective.

Table 1 shows the combination of different interventions performed in the separate groups

Table 1: Intervention formats according to groups

Intervention format	Experimental group 1	Experimental group 2	Control group
Kick-off event	✓	✓	
Webinars	✓	✓	✓ (delayed)
Web Forum	✓	✓	
Precycling Starter Kit & Workbook		✓	
Online group discussion		✓	
FAQ	✓	✓	✓ (delayed)

In experimental groups 1 and 2, the interventions took place simultaneously. In the third group, the control group, there was initially no intervention during the intervention phase (week 1 to 4). Instead, participants continued with their conventional everyday life while the other groups participated in workshops and other interventions. After the intervention phase, interventions in the control group took place in a content-shortened form until week 6.

2.4 Methods of data collection

In the beginning, middle, and end of the HomeLab study, data was collected extensively in the form of online surveys, packaging diaries, waste collections, online interviews, and online group discussions. However, the methods of data collection differed to some extent among participants, depending on which group participants were assigned to (see Table 2).

Table 2: Data collection methods by groups

Data collection methods	Experimental group 1	Experimental group 2	Control group
Online survey	✓	✓	✓
Packaging diaries	✓	✓	✓
Waste collections <i>Note: waste was collected randomly from 11 households per group.</i>	(✓)	(✓)	(✓)
Online interviews		✓	
Online group discussions		✓	

The impact of the interventions was measured by collecting information on the status quo of packaging consumption and on the precycling behavior of households in all groups. The online survey and interviews were used to investigate which precycling behaviors the participants reported themselves (e.g., reuse of packaging). Complementary to this, the results and consequences of this behavior were recorded through

the packaging diaries and waste collections (e.g., number and amount of packaging waste generated). Through these different perspectives on and information about domestic packaging waste developments, we tried to gain a comprehensive understanding of precycling behavior. The methods for data collection are described in more detail below.

Online survey

In the online survey, the participants were asked about different aspects relating to the topic of precycling, including their personal habits and their perception of food packaging. The participants were asked to assess their agreement with various statements, e.g. "I consciously buy unpackaged food" or "I produce comparatively little packaging waste from food products". In addition, the participants were asked specifically whether they reuse or continue to use packaging, e.g., whether they reuse accumulating packaging such as bags, either for the same or a different purpose, or whether they bring reusable bags or containers with them when they go shopping (reuse behavior). They also answered questions about their attitudes and goals related to precycling, their motivation to participate in the study, how they experienced their participation in the HomeLabs and what this meant to them and their households. The online survey was administered three times with all participants: the first time prior to the HomeLabs in May, the second time after the intervention period in June, and the third time from late October to early November 2021. Participants in the control group answered it a fourth time in July, after they had taken part in a staggered intervention (see Figure 4).

Packing diaries

In the packaging diaries (see Figure 2), all food packaging was entered that the households produced over a week. The households were asked to record various information about the packaging: for example, the type of material, which food and in what quantity it had been packaged, and what the disposal route of the packaging was. A reader with corresponding information was given to the participants in addition to the diary template to ensure the correct assignment of the type of material. The entire packaging of a food product should have always been entered as a whole piece; for example, in the case of a jar with screw top, the top was counted as part of the packaging and not considered separately. The packaging diaries were filled in by all participants at several points in time: Before the start of the HomeLabs in May, during the intervention phase, after the intervention phase in June, and at the end of October. The households of the control group additionally filled out the packaging diaries an additional time in July (see Figure 4)

Ausfüllhinweis: Bitte dokumentieren Sie jeden Tag Ihre Verpackungsabfälle. Bitte verwenden Sie pro Verpackung eine Zeile, gehen für diese jeweils die Schritte in der Anleitung durch und tragen die Informationen in den Bogen ein. Falls die Produktverpackung aus mehreren Teilen besteht, tragen Sie diese bitte zusammen in eine Zeile ein.

Nr.	Schritt 1: Wochentag	Schritt 2: Produktbeschreibung		Schritt 3: Packmitteltyp			Schritt 4: Material und Recyclingcode		Schritt 5: Entsorgungsweg und weitere Nutzung der Verpackung	
		Welches Lebensmittel wurde durch die Verpackung verpackt?	Gewicht oder Volumen des verpackten Produktes [x kg oder x l]	Um welchen Packmitteltyp handelt es sich? [Packmitteltyp]	Bemerkung	Anzahl	Aus welchem Material besteht die Verpackung? [Materialgruppe]	Ist ein Materialhinweis oder ein Recyclingcode auf der Verpackung vorhanden? Wenn ja, welcher? [Recyclingcode/Materialhinweis]	Was haben Sie nach Gebrauch mit der Verpackung gemacht? [Entsorgungsweg, A1-S; B1-2/C]	Haben Sie die Verpackung wieder- oder weiterverwendet? Wenn ja, wofür? [Einsatzbereich]
96	Mo	Milch	1l	Beutel		1	Kunststoff	40% Kreide	A2	nein
97	Mo	Limonsuppe	0,4 l	Becher		1	Plastik Kunststoff	PEFC	A5	"
98	Mo	Salami	80g	Folie			Kunststoff	-	A2	"
99	Mo	Spätzle	0,4kg	Folie		2	Kunststoff	-	A2	"
100	Mo	Meer	0,3kg	Schachtel		1	Pappe		A1	"
101	Mo	Brötchen		Beutel		1	Papier, Kunststoff		A5	"
102	Mo	Schulbrot		Beutel		2	Papier		A1	
103	Di	Hefeflecken	0,5kg	Beutel		1	Papier		A1	nein
104	Di	Birnen	1,0kg	Schachtel		1	Plastik		A2	"
105	Di	Milch	1l	Beutel		1	Plastik	40% Kreide	A2	"
106	Di	Champignons	0,3kg	Schachtel		1	Plastik		A2	
107	Di	Brokkoli	0,5kg	Folie		1	Plastik		A2	
108	Di	Mozzarella	125g	Beutel		1	Plastik		A2	
109	Di	Süßigkeiten	100g	Folie		5	Plastik		A2	
110	Di	Gurmi	110g	Schachtel		1	Pappe		A1	
111	Mi	Süßigkeit	300g	Schachtel		1	Pappe		A1	
112	Mi	Joghurt	500g	Becher		1	Plastik		A2	
113	Mi	Tomatensauce	1,5	Beutel		3	Plastik		A2	
114	Mi	Musli	500g	Beutel		1	Plastik		A2	
115	Mi	Käse	200g	Schachtel		1	Plastik		A2	

Figure 2: Example of a completed packaging diary

Waste collections

To evaluate the influence of the interventions on the amount of waste in the households, random samples from eleven households per experimental group, i.e., from a total of 33 households, of all waste except for the organic waste garbage bin were collected and analyzed. For this purpose, the households were provided with garbage bags of 120 liters each to ensure a uniform bag size for the weight determination. In the first step, the collected waste was pre-sorted into packaging waste and non-packaging waste. Only the packaging waste was then characterized separately by household and according to the categories residual waste, lightweight packaging (yellow bin), paper/cardboard/carton, and glass. During this main sorting, the waste was then divided into three size classes (smaller than 40 mm, 40-80 mm and larger than 80 mm) using a two-stage screening process. The particles larger than 80 mm, i.e., entire packaging or individual packaging components such as lids, shredded packaging parts such as torn/cut boxes or bags, were then characterized in detail. Properties such as mass, shape, size, material, color, packaging type and product type as well as quantity were recorded. It was also noted whether packaging particles were present in aggregates such as yogurt cups stuck together, burger boxes including napkins and cutlery, and more. The condition of the packaging waste affects its ability to be sorted and therefore recycled and is hence an important factor, in addition to parameters such as size, mass and material, influencing the actual amount of material that can be recycled. The waste was collected at four points in time: week 0, week 2, week 5 and week 7 (see Figure 4).



Figure 3: Waste sorting in the Department of Circular Economy and Recycling Technology at TU Berlin

Online interviews

The online interviews were conducted only with experimental group 2's participants at the beginning of the intervention phase. They lasted about an hour and included questions concerning the organization of everyday life, the current use of reusable containers and the participants' experiences and thoughts around packaging and packaging avoidance. A second individual interview was then conducted with the same participating households during the follow-up survey in November. Here, the goal was to learn if the respondents who tried new behaviors in May could sustain their precycling behaviors, with a special focus on reuse practices.

Online group discussions

In the online group discussions, the participants of experimental group 2 could exchange their experiences with packaging avoidance which they tested as part of the workbooks. There was a total of three appointments for the online group discussions in Week 4, each lasting approximately two hours. Each household was able to participate in one appointment. Participants were encouraged to share their experiences during the HomeLabs, particularly on the tasks from the workbooks. During these sessions, packaging-intensive habits were shared, difficulties with packaging avoidance were revealed, and tips and tricks for precycling in everyday life were exchanged.

The chronological sequence of the interventions and data collection is shown in Figure 4

3. Participants – Who has participated in the HomeLabs?

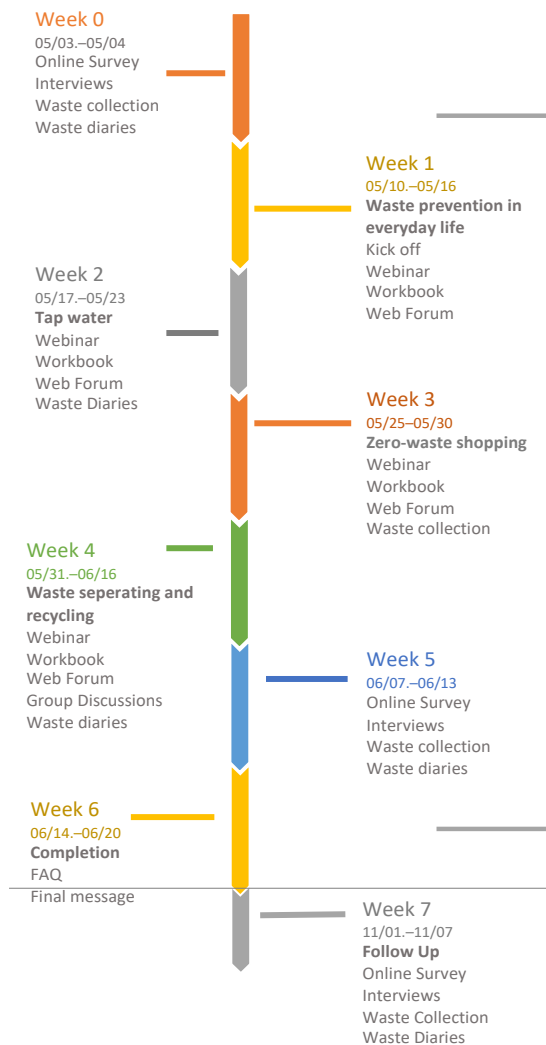


Figure 4: Timeline of the HomeLabs activities

A total of 126 people participated in the HomeLabs. Of these, most participants live in a family (37%) or couple household (26%). On average, 2.5 people live together in one household. The participants are on average between 30 and 40 years old. The average age is around 38 years. However, middle and older generations are also well represented – the oldest person is over 80 years old.

Furthermore, with 70% an above-average number of women participated in the study, men were only represented with 30%. It is also striking that many of the participants have a university degree (68%), which means that the level of education of the participants is above average. Many participants are employed full-time, with an average working week of 24.4 hours. This weekly working time results, among other things, from the high participation of students (30%).

4. Key findings – Precycling in everyday life

In the following, the results of the data collection are presented.¹ First, the results of the online survey and online interviews are used to show whether and to what extent the participants themselves perceived a change in their precycling behavior in general and reuse behavior in particular. Subsequently, the results from the waste sorting and packaging diaries are used to show to what extent these perceived changes are reflected in the actual amount and composition of waste generated over time. Finally, the actual and perceived separation behavior of the participants is described based on waste sorting, packaging diaries and online interviews.

4.1 Change of precycling behavior

In the online survey, participants were asked to assess their precycling behavior. For this purpose, the scale of Klug und Niemand (2021) was used in a slightly adapted form. It includes the following aspects: buying unpackaged food, buying sustainably produced food, targeted avoidance of packaging waste ('zero-waste approach'), reduction of packaging waste, and eliminating unnecessary packaging. The evaluation showed that the participants² rated their precycling behavior in week 0 with a value of 4.89 (on a scale of 1 to 7, see Figure 5).³ This indicates that the participants already practiced precycling behavior before the intervention and that there was an awareness of the topic among the participants.

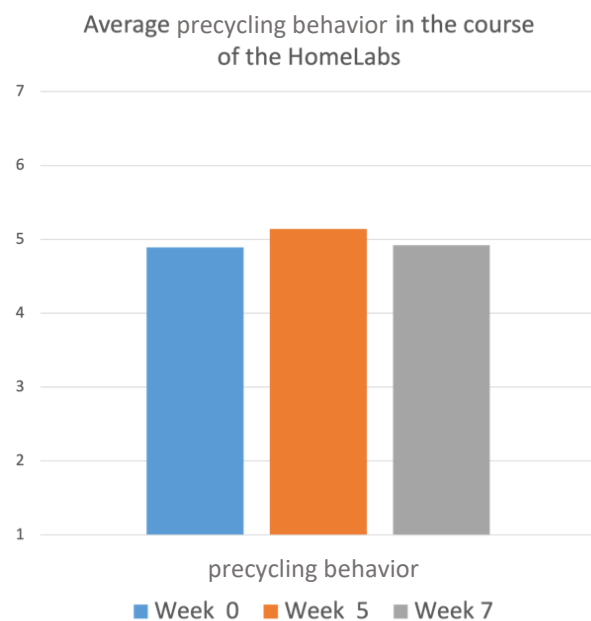


Figure 5: Average precycling behavior over the course of the HomeLabs

After the intervention phase (week 5), they reported on average slightly more precycling behavior than before. This means that, according to their own statements, the participants paid somewhat more attention to keeping their packaging waste as low as possible after the intervention phase. The participants particularly stated that they consciously bought (more) unpackaged and sustainably produced food to avoid unnecessary packaging waste. However, the self-reported precycling behavior was higher only immediately after the intervention phase. In the follow-up survey (week 7), the participants reported less precycling behavior.

These results from the survey are partly reflected in the reports of the interviewed participants. Some interviewees reported that after an initially intensified packaging reduction, older routines slowly crept back

¹ The results are based on a preliminary descriptive analysis. The data will be analyzed in more depth for disciplinary and interdisciplinary articles. In addition, some of the analysis of the packaging diaries and household waste had not yet been completed at the time of publication of the report, which is why the results only refer to the data from week 0 to week 5 (intervention phase, see Figure 4).

² The following results refer to different sample sizes. On the one hand, this results from the fact that participants took part in different intervention formats depending on the group (see chapter 3) and corresponding samples were drawn from the overall sample. On the other hand, fewer people participated in the surveys over time, so that the samples at the later measurement points decreased in some cases.

³ Note: To report their precycling behavior, participants estimated their agreement with various statements on a scale of 1 to 7, with 7 being "strongly agree" and 1 being "strongly disagree".

in, and they did not manage to maintain the initial euphoria and increased focus on precycling behavior:

In other words, falling back into old patterns. That's what I'm noticing. I can say that now: excuse, stress, work. When I had more time and took more time, I did it more consciously and it was easier. And in the peak time, I paid even more attention to it, because it was always more present. (Female, 45 years, single household)

The exchange with others and the incentives from the outside helped to change the behavior during the initial HomeLab phase. After the end of the intervention phase, some found it more difficult to continue pursuing their avoidance goals. The consistent integration of the new routines into everyday life was often not yet securely anchored, and initial successes therefore did not last until October, even though the first attempts to change routines were made. The interviews revealed that the daily routines were often experimented with first, in order to check which practices were suitable for the participants. New routines were adopted and adjusted, but also discarded (e.g., making one's own food). This could also indicate that a measurable precycling behavior may only settle in over a longer period of time.

Precycling was interpreted differently by the participants. For example, one participant reported that she had "become more disciplined" about avoiding single-use packaging for takeaway meals and switching to reusable alternatives (female, 42 years, single household). However, many of the participants have also been careful to avoid packaging waste, especially plastic, before their participation in the HomeLabs. For the interviewees, precycling predominantly means consciously buying unpackaged food. In this context, many participants report weighing up different packaging alternatives more carefully and actively taking more time for these decisions while shopping. In this context, packaging avoidance is not considered separately from other ecological consumption strategies: for example, avoiding food waste (e.g., through food sharing) or ecological food production. Overall, the intensive engagement with a wide range of topics related to packaging avoidance through workshops and the tasks in the workbook (see Figure 6) helped achieving a deep reflection and change in packaging-relevant behavior in some participants.

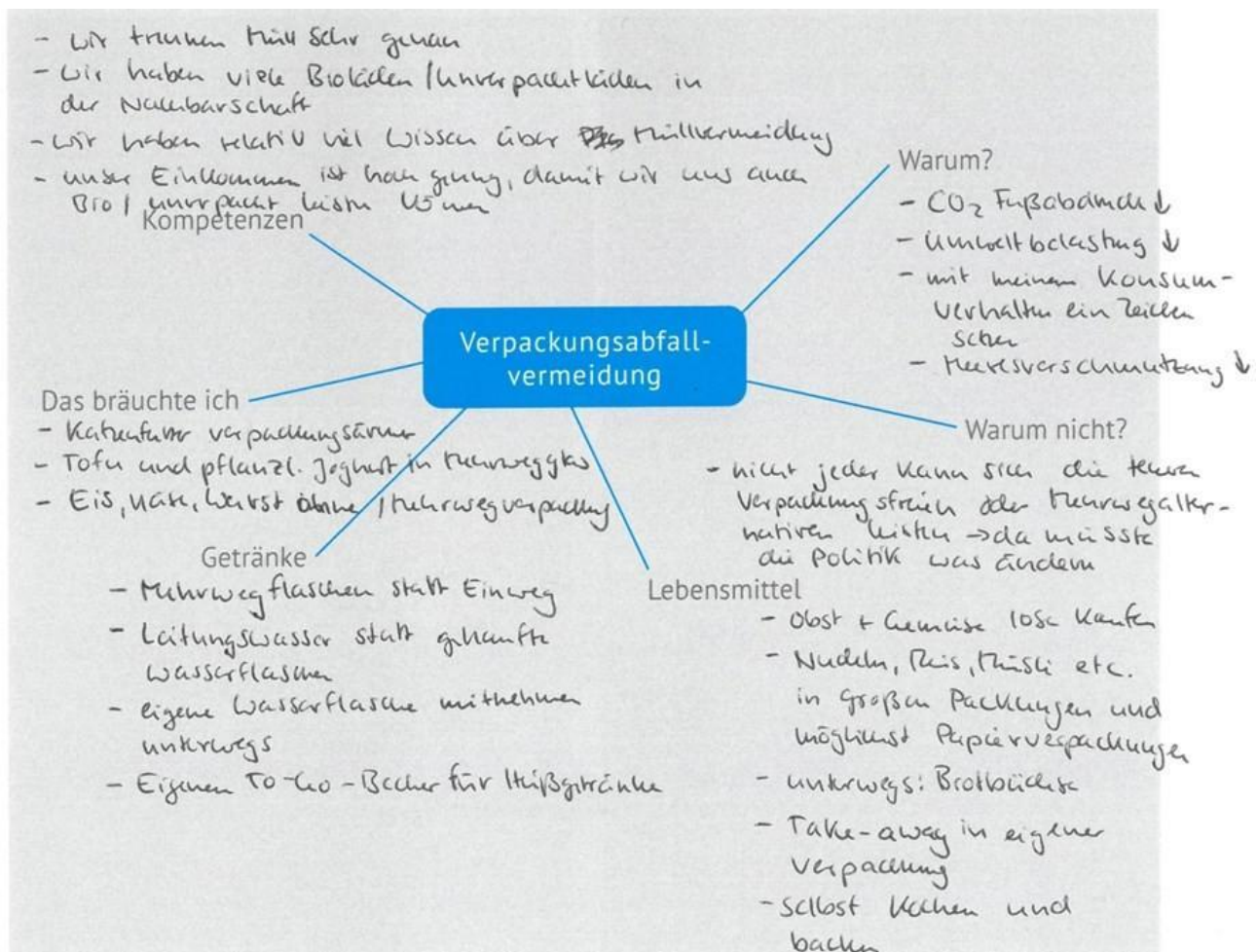


Figure 6: Example of a mind map on packaging waste prevention

Buying sustainably produced food is also an integral part of their precycling behavior for some respondents: many shop at organic markets or prefer sustainably produced food. In some cases, however, participants see far-reaching sustainability considerations as conflicting with low-packaging consumption:

And then there's always this inner question: okay, what do I pay attention to now? Do I want to avoid plastic somehow or do I want to keep the transport routes as short as possible? Although this example does not really work with a mango. Or do I just get the peppers in the plastic wrap organic or without plastic wrap from the greenhouse in non-organic or so.
(Female, 31 years, couple household)

The following routines for the reduction of waste according to the targeted avoidance of packaging waste according to a zero-waste approach were mentioned: Carrying their own bags and nets, shopping for fruits and vegetables without packaging, increasing the use of deposit systems, buying larger packaging sizes, and using collective supply options. Avoiding unnecessary packaging or products because of their packaging plays a marginal role in the interview data. However, some report abandoning oversized and multiple packaging. Few are willing to completely refuse a particular product because of its packaging due to a lack of low-packaging alternatives.

4.2 Change in reuse behavior

A scale based on Kaplan Mintz et al. (2019) and Robertson & Barling (2013) was developed to assess the reuse behavior in the online survey. The scale included items on reusing grocery bags, reusing disposable packaging for the same or different purpose, owning reusable containers for food and beverages, and using own containers for non-packaging stores.

The online survey suggests that participants in group 2 reported slightly more reuse behavior after the intervention (week 5). Group 2's participants particularly indicated that very often used their own shopping bags or sacks to bring food home and used them multiple times. They also often used reusable food and drink containers when they were on the go. Overall, they rarely or occasionally used their own containers to buy unpackaged food. In follow-up survey (week 7), participants in group 2 continued to report tending higher reuse behavior than before the start (week 0) of HomeLabs⁴.

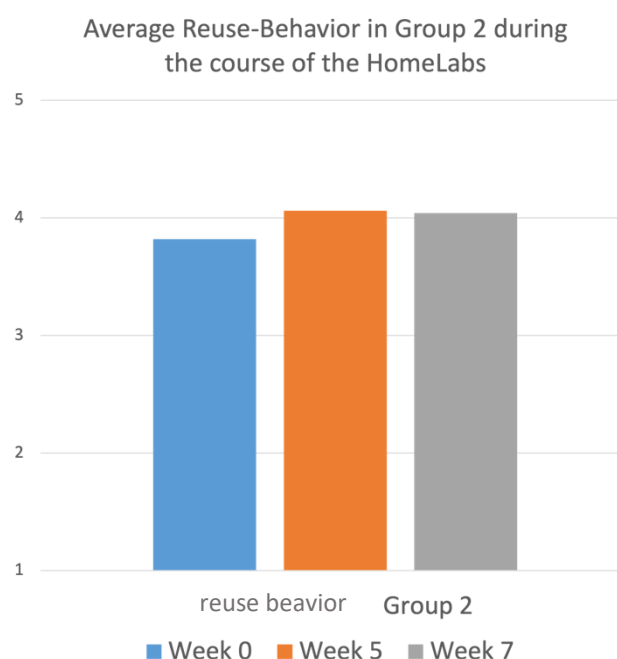


Figure 7: Average behavior in group 2 over the course of the HomeLabs

These results indicate that concretely trying out reuse practices and talking them through with others, as was achieved through the workbooks and the group discussions, may have conditioned a longer-term change in everyday routines. The interview and group discussion data provide evidence and insight that participants in group 2 developed new packaging repurposing practices and that they maintained their reuse behaviors over time. Some interviewees reported, for example, that they had discovered new ways of reusing disposable packaging for other purposes: "Then even these coffee bags, that's actually new, in case there's somehow still a waterproof bag for a wet cloth or something – small bags, they're not that big – that's also still there." (Female, 45 years, single household). Participants particularly frequently reported reusing large packaging, such as toilet paper packaging, as trash bags. Others could intensify repurposing practices, such as reusing bags or larger outer packaging, by collecting significantly more packaging than before the survey. However, for some, this resulted in too much packaging being stored. While not all of it could be meaningfully reused. A few respondents countered this by researching for upcycling ideas for crafting with packaging via the Internet.

⁴ Note: To self-assess reuse behavior, participants rated how often they implement a particular reuse behavior on a scale of 1 to 5 for a total of six different questions, where 1 meant "never" and 5 meant that they do it "very often."

The repurposing of jars was particularly popular; these are often used for zero-waste shopping or storing other foods. Bringing one's own bags for shopping was already widespread before the participation in the HomeLabs. However, after participation, many were even more meticulous about distributing shopping bags in backpacks or purses and were consequently able to intensify their reuse behavior.

The workbooks and interviews show, that many respondents have an overabundance of reusable containers, and some are dissatisfied with the existing storage systems. As a result of reflecting on this overabundance because of the workbooks and interviews, some respondents sorted out containers or assigned better locations to reusable containers in regular use.

The data from the workbooks and interviews does not show any major changes in the use of reusable bottles for tap water: almost all participants had already previously integrated tap water from their own containers into their daily lives (see Figure 9).

However, some reported buying new bottles and thus avoided one-way alternatives even more consistently. A few are skeptical about public drinking fountains or criticize their availability outside of urban areas.



Figure 8: Storage of reusable containers in the household



Figure 9: Photo of a drinking bottle



Figure 10: Storage of reusable containers in the household

Most of the HomeLab participants in group 2 had already taken home-prepared meals to work or university in their own containers before participating in the HomeLabs. However, some of them do not use additional foil or disposable packaging for the food they bring any more. Barriers to bringing their own food in reusable boxes were primarily the lack of availability of a microwave or a kitchen at the workplace. The reusable boxes provided in the starter kits were used regularly and were well received by many of the participants. However, on longer trips to places like museums etc., the reusable containers were not so readily taken by some participants, who preferred to dine spontaneously in restaurants and accept disposable packaging for any leftover food. In some cases, the containers were also rejected due to Corona hygiene regulations (see Figure 9).



Figure 9: Experiences with the use of reusable containers

Shopping at a zero-waste store was the most poorly received reuse practice and the most barriers were reported here: Price, logistics, effort, distance, corona-related hygiene concerns, spatiotemporal integrability into daily life, product variety, container management, package size, and lack of scalability were cited as barriers. In terms of frequency of zero-waste shopping, four trends can be observed: 1) for some respondents it is not an option at all, 2) others only go to the zero-waste store for very specific products, 3) respondents who previously shopped infrequently at the zero-waste store have been able to increase the number of products they buy there, and 4) a few who did not visit a zero-waste store before now buy large quantities there weekly. Zero-waste shopping is also associated by some with positive feelings, making it easier to carry out the practice - for some, shopping even becomes a happening:

And precisely because of this we have now started to shop in the zero-waste store, and I continue to do so (...) Yes, and I also find that quite nice in the meantime and I also like to go there and it's such a good feeling. That is actually the main change that has taken place".
(Female, 50 years, couple household)



Figure 10: Experiences with shopping in an zero-waste store documented in the workbook

4.3 Change in the quantity of domestic (packaging) waste

Another key question of the study was to what extent the perceived changes in precycling and reuse behavior described above were reflected in the amount and composition of household waste generated by the participants. The waste sorting showed that between beginning (week 0) and end of the intervention phase (week 5), the total waste quantities decreased in both the experimental groups and control group, although the reduction was more pronounced in the experimental groups. The development differed depending on the waste group (i.e., lightweight packaging/yellow bin, glass, paper/cardboard/carton, and residual waste): In the experimental groups, all fractions decreased except for waste glass, the amount of which increased slightly. In the control group on the other hand, all fractions decreased except for paper waste, the generation of which increased significantly. These are mean values per capita across all households.

Developments within individual households or between households were much more dynamic. Thus, individual fluctuations due to special events in the daily lives of households (such as business trips, moving apartments, celebrations, etc.) probably had a major impact on the data. However, this cannot be said with certainty due to the relatively short observation period. Also, the weather may have influenced eating habits and thus impacted the total waste trend. The weather in week 0 for example was still comparatively spring-like, whereas in week 5 it was already clearly midsummer with daytime temperatures between 30°C and 35°C. This usually leads to an increased consumption of beverages, fruits, and other food products. These so-called seasonal effects are well-known effects in waste management research. The seasonal effects may override the intervention effects of an increased awareness and application of precycling activities due to the short period of the study.

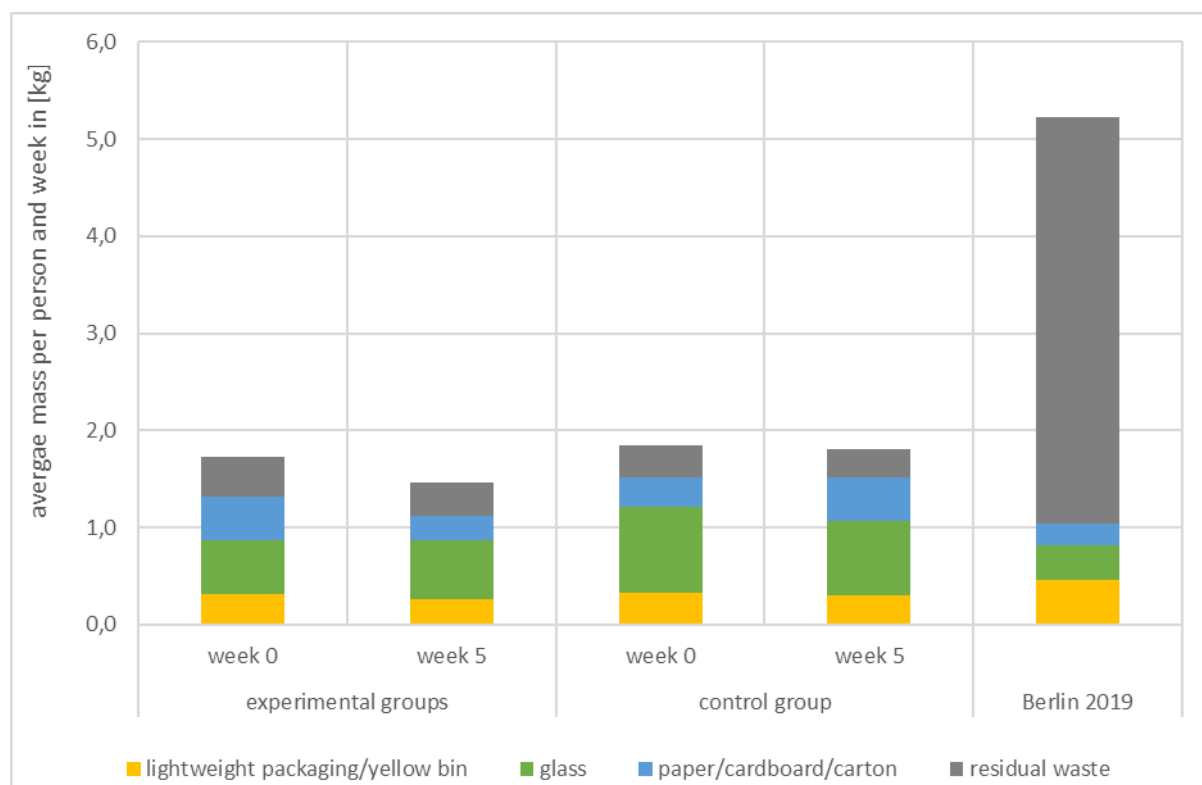


Figure 11: Total waste mass and mass of all four waste fractions for week 0 and week 5 in comparison to the average for Berlin

The comparison of total waste generated by participating households with all households in Berlin for 2019 (calculated per capita per week) shows that the HomeLab households produced slightly less lightweight packaging and paper/cardboard/carton while slightly producing more glass, but only a small fraction of the residual waste generated compared to average households in Berlin (Senate Department for the Environment, Mobility, Consumer and Climate Protection 2019.).

There are various reasons for the high proportion of residual waste produced by the average Berlin household. For example, many households still do not have an organic waste bin, which is why all food waste ends up in the gray waste bin for residual waste. Furthermore, not all citizens use the organic waste bin, even if they have access to it. In addition, separation behavior varies greatly between people, households, and districts. Many households do not separate their waste; instead, they dispose of all waste in the residual waste (Senate Department for the Environment, Mobility, Consumer and Climate Protection 2019.). The data for Berlin also depicts residual waste from small businesses in addition to residual waste from private households. However, even if this share for small businesses is excluded, the average amount of residual waste for Berlin in the graph is only slightly reduced. Hence, the residual waste generated by HomeLab participants overall is lower than in average Berlin households. This indicates that regarding their handling of waste the participants in this sample overall differ positively from the average Berlin households.

The evaluation of the packaging diaries shows, the number of packages collected in the HomeLab households was lower after the end of the intervention phase (week 5) than at the beginning. Thus, after the completion of the intervention phase per person, in both the experimental groups and the control group, approximately five packages less were generated per week (see Figure 12). This corresponds to a reduction in the number of packaging of roughly 19%. The maximum number of packaging used per week also decreased. The household with the most packaging items (173) had, for example, around 60 packages less after the end of the intervention phase than at the beginning of the study.

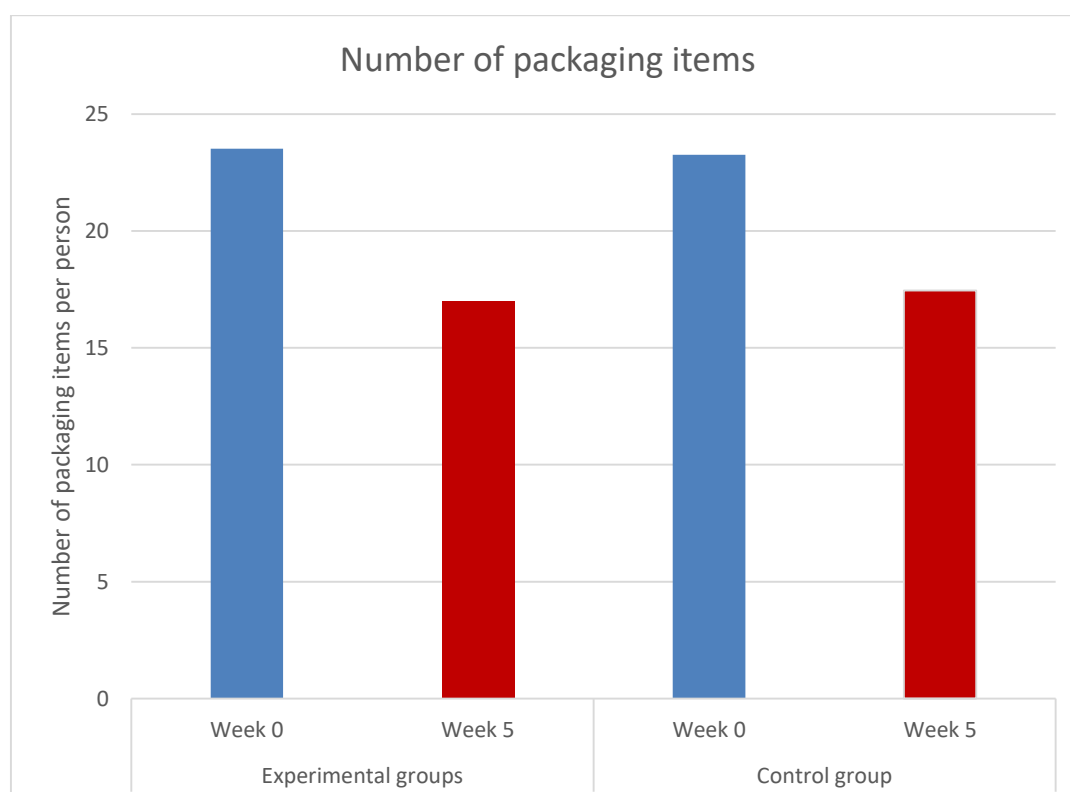


Figure 12: Number of packaging items

The qualitative interviews show that the amount of packaging waste was assessed in a diverse manner by the participants themselves. Some participants report that they have been able to reduce the amount of packaging they produce. However, these changes are not always attributed to the interventions of the HomeLabs, but partly to changed living conditions. According to the participants, a changed work situation, living constellation or relationship status had a noticeable effect on their packaging volume. Some participants also found it difficult to attribute their own packaging volume to increased awareness and precycling behavior due to the strong seasonal change in their nutritional practices: "Now, of course, it was also summer, for us it's the case in summer, that we eat a lot in the garden, for example, and then also buy a bit less packaging accordingly" (Female, 53 years, family household). Some of the interviewees, on the other hand, attributed their reduced packaging volume to purposeful shopping for unpackaged products: "Yes, shopping in zero-waste stores has already reduced it. All this plastic packaging, like for cereals and such. We don't have them anymore" (Female, 60 years, couple household). It is also noteworthy that some respondents report that they have been able to reduce their packaging volume without any specific goals or conscious efforts:

Now we don't know what caused us to reduce our plastic waste from two bags between pickups to one. However, it happened. But it also stayed the same and also this one bag that we then put out for collection is also not so particularly full. So anyway, but now without concrete goal. Has probably crept in." (Female, 31 years, couple household)

Other HomeLab participants estimate their packaging waste to have remained constant during the study period. These are predominantly the participants who already had a subjectively low packaging volume and had already integrated intensive precycling behavior into their everyday life. Therefore, they were no longer able to achieve any major changes because of participating in the study. For example, one participant reported: "I have the feeling that I can no longer really reduce it. That would mean a lot of giving up and I don't really feel like doing that, to be honest" (Female, 23 years, single household). Participants who mainly obtain their food via food sharing also report no significant change, as they don't have freedom over the choice of products. In some rare cases, the subjectively reported amount of packaging has also increased; this was put in a context with food deliveries and the newly practiced food sharing: "But otherwise I don't think that much has changed. Except that food sharing has simply changed everything, that I really have more waste since then, but that's just the way it is now" (Female, 23 years, single household).

The packaging diaries revealed that the packaging material changed throughout the study. A decreasing share of composite packaging can be observed in all groups, with the decrease in the control group from 18% to 5% being very significant. An increasing share of packaging made of glass and PCC (paper, cardboard and carton) can also be observed in all groups. A slight increase in the proportion of plastic packaging can be observed in the control group (from 45% to 51%), although the absolute number of packaging has not changed. Thus, in week 0 as well as in week 5, approximately ten packages made of plastic are used from each person of the control group. The share metals, which include aluminum and ferrous metals, remain constant in both groups at about 3%. Only 0.5% to 2.5% of the packaging were not specified. A more in-depth analysis of the data is planned as part of the consolidation with the data from the waste analysis.

Figure 13 shows whether there was a constant share of the material type (right arrow), increasing share (up arrow) or decreasing share (down arrow) in each case. A constant share is assumed if the share of the material group changes by less than 2%.

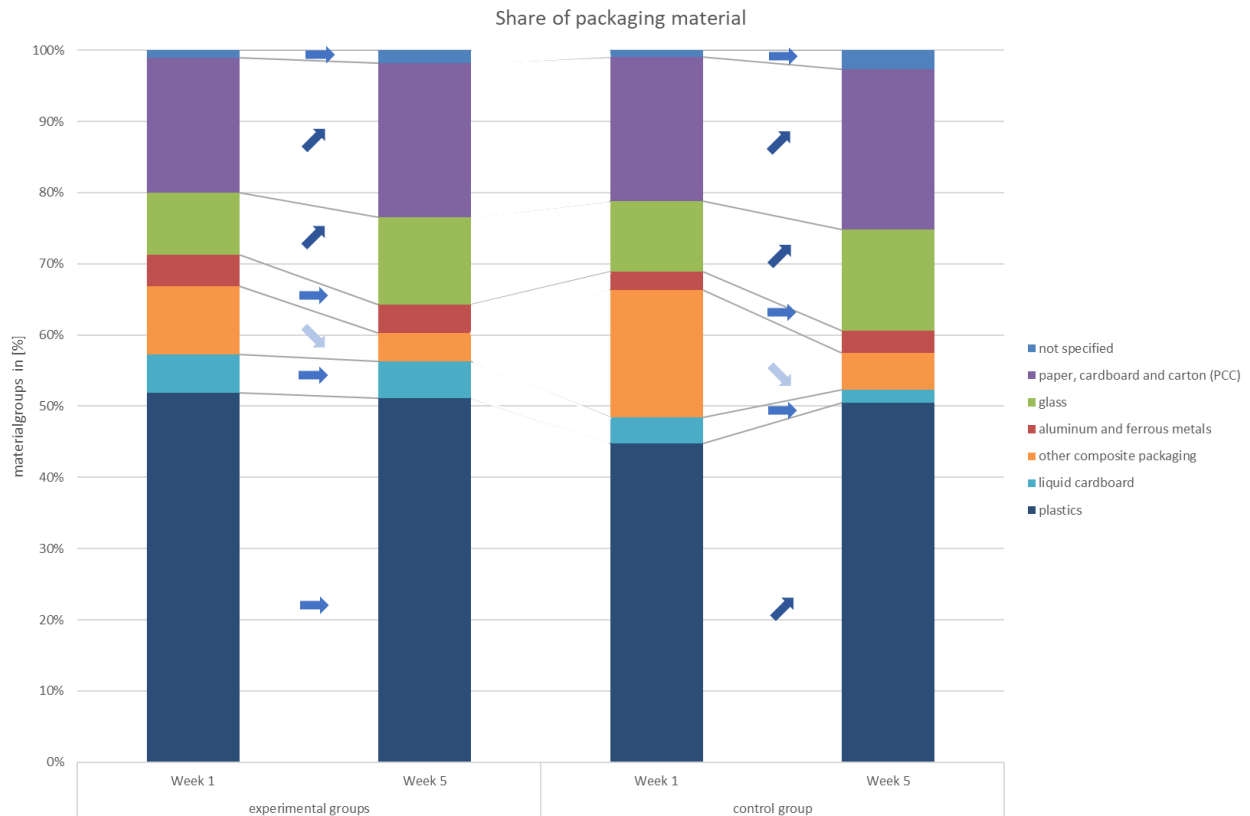


Figure 13: Share of packaging materials

Regarding the material type of the packaging waste, the participants reported similar changes in the interviews: they tried to buy more glass packaging to avoid plastic packaging in particular. Especially Milk and yogurt products were increasingly purchased in jars: "And also with milk and yogurt products at least I try to buy in a glass. So that I pay a bit of attention to it." (Female, 25 years, shared apartment). Although many have also tried to reduce plastic packaging, they report that this is still very difficult for specific products. Particularly in the case of dry products such as pasta and rice they complain about the lack of material alternatives:

Actually, I would also like to improve it, so I would totally like it if we used less, much less - I think we still use way too much plastic, so to speak. I would like to have alternatives for the things that we often eat, I would say, like noodles, rice or something. (Female, 53 years, family household)

4.4 Change of separation behavior

The waste sorting by the research team allowed to determine how the waste packaging was disposed of. Looking at the composition of the waste in terms of the share of packaging and non-packaging (i.e., the proportion of packaging waste in the garbage bag compared to other waste), a very positive picture emerges regarding the participants' separation behavior. The share of packaging in the yellow bin as well as in the glass waste was very high from the beginning and was (almost) 100%. The reasons for this are, on the one hand, a good separation performance of the participating households and, on the other hand, by definition, only packaging waste goes into these specific waste bins. The situation is different for paper/cardboard/cartons (PCC). Here, packaging generally makes up a relevant proportion, but so do, for example, printed matters such as newspapers, magazines or advertising. This is also reflected in the results of the HomeLabs, where the share of packaging in the PCC garbage can was between 45% and 65%. In both

the experimental groups and the control group, the share of packaging in the PCC bin increased between week 0 and week 5. This indicates both better separation performance over time in the HomeLabs (more correctly separated packaging in the paper garbage can) and possibly increased precycling activities that led to the avoidance of other paper waste such as printed matter.

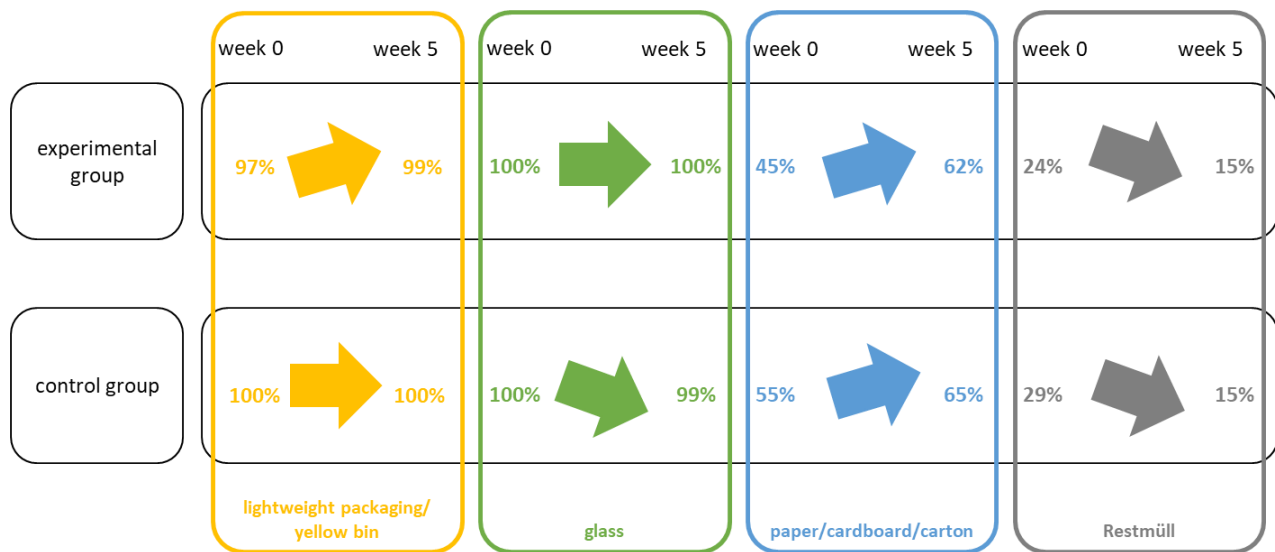


Figure 14: Share of packaging within the four waste fractions for week 0 and week 5. The percentages represent the mass share

The proportion of packaging in the residual waste, has decreased in both groups. Both the experimental groups and the control group have therefore increased the share of correctly disposed packaging, which supports a better recycling. Which is especially important in Berlin as the residual waste is directly incinerated at a waste-to-energy plant, without being sorted beforehand.

No significant change in the number of misthrows could be detected throughout the HomeLabs. We speak of a misthrow when, for example plastics are disposed in the PCC bin. Proper disposal in this example would be the disposal in the yellow garbage bin. Disposing of packaging in the residual waste also represents a misthrow, since important resources are lost as a result, but this type of misthrow does not lead to any problems in recycling plants. Therefore, we have listed the proportion of packaging in residual waste as an additional category (see Figure 15).

The proportion of misdirected waste in the HomeLabs, with overall around 5%, is below the German average, which according to the German Association for Secondary Raw Materials and Waste Disposal can be up to 60% (bvse 2018). Furthermore, the 5% figure could even be an overestimation of the actual misdirected waste. Errors in the analysis may have occurred due to wrong determination of the material type by the households. When analyzing the data from the packaging diaries, it was found that Tetra Pak packaging was sometimes assigned to the material PCC, although these were liquid cartons. As a result, disposal in the yellow garbage can was categorized as a false throw, even though the liquid cartons were disposed of correctly.

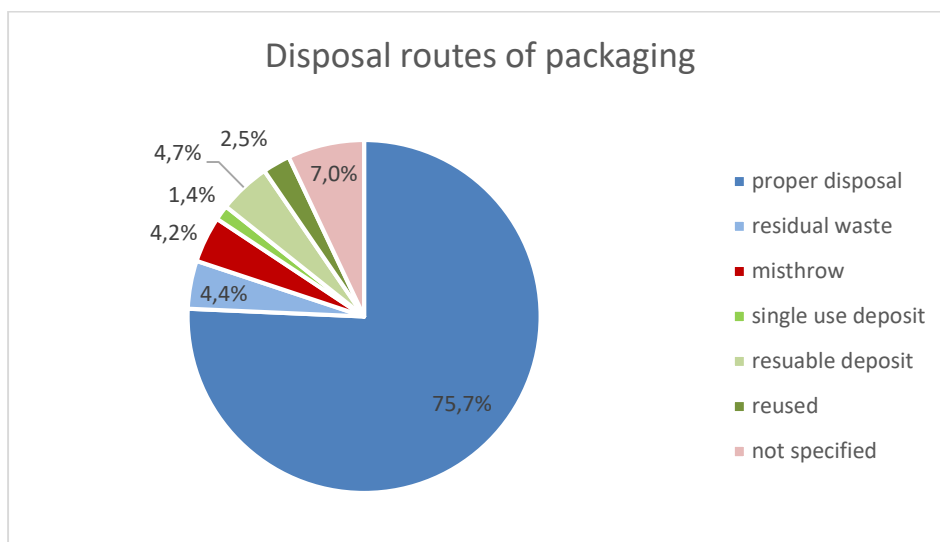


Figure 15: Disposal routes of packaging

Therefore, it can be assumed that despite post-processing of the data, not all incorrect entries were founded and corrected. This is due to the large volume of data (several thousand entries).

The reusability rate for beverage containers is significantly higher among HomeLab participants (77.4%) than the average of the German population (41.8% in 2019, see Cayé & Leighty 2019). This could be the result of the high degree of usage of refillable water bottles and the consumption of tap water. Another observation is that almost all deposit packaging was beverage packaging. At 2.5%, a relevant proportion of packaging was reused. The purposes of reuse included the use for storage or as jam jars.

Behavioral changes concerning waste separation are also reported in the interviews. Many separate wastes more carefully and consistently because of the HomeLab interventions:

So separating paper from foil or these lids from the yogurt pots or things like that. So little things that I didn't even know about or didn't do consciously, I definitely do more now, more focused than before. And otherwise, I don't think anything has changed much in that direction. Because the basis was basically already there before. (Female, 42 years, single household)

The knowledge-centered interventions through the webinars seem to have had an impact in this area. Some of the participants bought new waste garbage cans or set up waste stations during the HomeLabs and report the positive impact on their separation behavior:

My garbage station from back then that I built there, it's still [as it was in May]. I think that's quite good, because it's neater than before, before PuR, better separated. So how do I say this? Trash can is trash can, but [you can have] a nice and not so nice one. And that's where I tried to optimize my separation station, that's what I call it. Because I say, if it doesn't look nice, maybe I won't separate it, if I make it a little bit fancier, I see it better and then it's easier for me, which in my case it actually is then. (Female, 45 years, single household)

5. Conclusions – What have we learned?

The aim of the HomeLab study was to understand precycling behavior in general and reuse behavior in the domestic context. The central question was whether and how precycling and reuse behavior can be influenced through interventions and whether these measures also lead to an actual reduction in the amount of packaging waste in households. For this purpose, social science and engineering methods of data collection were combined and interventions on different aspects of precycling in everyday consumption were carried out in cooperation with practice partners. In the following, the central findings of the study are summarized and based on this, we address implications for practice and policy as well as further research needs. Please note that these results are preliminary; final results will be discussed in other peer-reviewed journal articles.

5.1 Central findings

The results indicate that the study participants realized somewhat more precycling during the phase in which the interventions were run. The participants considered precycling to be a very wide range of different strategies and behaviors, such as the purposeful avoidance of plastic packaging, the reuse and recycling of disposable packaging or the production of one's own food. The increase in precycling behavior seems to have had a positive impact on the actual amounts of waste produced by households during the study period: the amount of packaging waste decreased slightly after the intervention phase. However, in the November follow-up survey, this effect was not maintained for the precycling behavior in general⁵. However, the participants had already practiced precycling before the study participation and they differed from the federal population in the way they handled waste. An example of this can be seen in the HomeLabs households' separation behavior: they separated and sorted their packaging waste better than the German average, as is shown by the low rate of misplaced waste (see Section 4).

HomeLab participants also performed very well in terms of the usage of reusable bottles: two-thirds of beverage containers were reusable deposit bottles, far exceeding the nationwide reusable rate of 41.8% (Cayé & Leighty 2019). And about 87% reported drinking tap water very often. Because of these good "starting conditions," the potential for household savings is correspondingly lower. In addition, it may be that completing the packaging diaries, which all study participants* had to fill out, created an awareness of their own waste, and thus led to less waste being generated in all households throughout the study period.

Looking at the preliminary data on reuse behavior, group 2 appears to be practicing reuse of packaging beyond the HomeLabs intervention phase. This group participated in a special intervention on reuse: not only were they given information on the topic of reuse, but they were also sent reusable boxes to try out and given tasks in the workbook that encouraged practical application and documentation of these everyday experiences. In addition, they had the opportunity to share their experiences in guided group discussions. The observations suggest that trying out and experimenting with new behaviors along with interactive exchanges can promote reuse practices. This confirms the effectiveness of practice-based interventions that are less focused on solely communicating information about environmentally friendly behaviors and instead address social practices (e.g., Laakso et al. 2021).

Despite this promising trend, the data also show that there is still some fear of contact with the reuse

⁵ For the follow-up survey, only the preliminary data from the survey and interviews are available at the time of publication of the report; the evaluation of the waste and packaging diaries is still pending.

behavior as soon as the containers are used outside the home. Consumers do not want to do anything "wrong", e.g., not closing the lid properly, spilling something when filling the container etc. This is especially true for bringing one's own containers to restaurants and shopping at zero-waste stores. But there are also concerns about using public drinking fountains for one's own water bottle. The challenges faced when shopping for unpackaged products reported by the participants during the trial show that the offer is still perceived as too small for zero-waste shopping to become a widely spread practice. Zero-waste shopping tends to be the exception as it involves a lot of restructuring of everyday life and is more time-consuming. These results are also confirmed in other studies on zero-waste shopping (Wiefek et al. 2021; Fuentes et al. 2019; Zeiss 2018).

5.2 Implications for practice and policy

How are these findings relevant for practice and policy? Packaging avoidance in the everyday life of consumers seems to include many behaviors that are often not consciously practiced. These behaviors and consumer strategies go beyond the purchase of optimized sustainable packaging and also include, for example, the avoidance of food scraps or the own production of food (cf. also Wenzel & Süßbauer 2021). The household's motivations for participating in the study and targets were also very individual in some cases: many wanted to avoid plastic packaging above all, while others named very specific fields in which they wanted to achieve a reduction, e.g., for certain products with a high proportion of packaging (e.g., fewer sweets) or for certain types of packaging (e.g., fewer Tetra Paks). Still, others took it upon themselves to better integrate new practices into their daily lives, e.g., shopping more often at the zero-waste store or in the zero-waste section of a supermarket. These household-level goals were rarely expressed numerically in terms of kilograms or the number of trash bags. These results show that from a consumer perspective, precycling cannot be reduced to a zero-waste lifestyle, i.e., completely eliminating packaging. Changes in routines usually happen gradually and the starting point can vary greatly depending on dietary habits. Consumer policy should therefore consider packaging avoidance integrated with other sustainability issues (in the food sector).

The focus on the avoidance of plastic packaging was consolidated by the study participants in the course of the intervention phase, although the content and interventions of the HomeLabs did not focus on plastic packaging but addressed all types of materials. After the intervention phase, a decreasing share of packaging made of (plastic) material composites and an increasing share of packaging made of paper, cardboard and carton (PCC), and glass could be observed in the waste of the HomeLab households.

However, many participants in the study already practiced plastic avoidance before the study and often reported this to be the reason for their application to HomeLabs. Plastic packaging, however, is not ecologically "worse" across the board; instead, it depends on the individual case - so it maybe that disposable glass is ecologically less sensible than, for example, a Tetra Pak. It also depends on the type of plastic and the requirements of the product on the material, e.g., liquid foods must be packaged differently than dry foods (ifeu 2021). The common myth that plastic packaging is less sustainable than glass or paper packaging has also been noted in other studies on consumer behavior (e.g., Otto et al. 2021; Cat-Krause et al. 2021).

It is not only important to educate consumers, but above all to oblige manufacturers and retailers to label packaging uniformly, to omit confusing information on the packaging, and, if possible, to provide information on the actual resource consumption or the environmental impact of the respective packaging to counter such myths with specific knowledge.

5.3 Limitations and further research needs

The study has some limitations. First, at the time of the publication of this report, not all data had been evaluated to the end. This mainly concerns the data from the packaging diaries and household waste from the follow-up survey. In addition, we have not presented all the results in this report but have limited ourselves to those relevant to the research question. These data will be analyzed and used in more depth for disciplinary and interdisciplinary publications in the future. For example, from a psychological perspective, it is interesting to see what influence social group processes, perceived self-efficacy, and problem awareness of the waste crisis have on precycling behavior (Wenzel & Süßbauer 2021). Also, the role of socio-demographic factors such as household type, age and gender could still be studied, for example, whether women report different precycling behavior than men. From a sociological perspective, it is interesting to see how reuse practices such as transporting, cleaning and storing reusable containers at home can be integrated into everyday life and what role the aspect of time plays in stabilizing these practices (Süßbauer et al. 2021). From an engineering perspective, it is interesting to see what ecological impacts the different packaging strategies of the participating households have. In particular, whether precycling in sum leads to packaging strategies with lower environmental impacts or if possibly opposite results could be observed.

A second limitation is that due to the Corona pandemic, all interventions and - except for packaging diaries, waste collection and the workbooks - all surveys took place digitally. On the one hand, the exchange between participants was therefore probably less intensive or long-term than it would have been through face-to-face meetings. The relationship between the research team and participants was also constricted by digital communication, which may have influenced the results (e.g., a higher dropout rate due to a lack of trust). However, participants may have been particularly motivated precisely because of the unique situation of the Corona pandemic, as the study provided social interactions and meaningful engagement, which many missed after the long lockdown from January to April 2021 and the associated contact restrictions.

Thirdly, results may be skewed by seasonal effects, special events such as moving or vacations and Corona pandemic containment measures. For example, more beverages tend to be consumed in the home during the summer, which in turn may have an impact on the amount of waste generated in the form of bottles. This effect may even have been exacerbated by the Corona pandemic, as at the time of the study, catering establishments were only open to a limited extent and travel options were restricted. For future studies, it would therefore be fruitful to conduct HomeLabs over a longer period than half a year to enable the exclusion of seasonal effects.

Fourthly, it would be interesting for future research to see how consumer tips on individual packaging materials and the clarification of "packaging myths" would affect the amount and composition of waste. For example, the targeted elimination of plastic packaging, which was practiced by some participants*, could result in shifting effects toward other, more resource-intensive packaging. In addition, it would be interesting to conduct practice-based interventions not only on precycling and reuse but also on other forms of precycling such as composting organic waste and growing or producing your own food. The study showed that consumers have a very broad and concrete understanding of precycling that may not be comprehensively captured in this diverse form by the scale of Klug & Niemand (2021) that we used in the survey.

Fifth, future research should aim for more diversity regarding the socio-economic background of the participants. Since many of the participants heard of the study via BUND or via the TU Berlin's Twitter account, there is a bias towards higher educational attainment and ecological orientation. Future studies could try to reach a more balanced and representative sample via other recruitment channels (e.g.,

associations, community centers). The use of these recruitment channels has been difficult due to contact restrictions resulting from the Corona pandemic. It would also be interesting to compare different cities as well as explore precycling practices in rural areas.

6. Sources

- Bundesverband Sekundärrohstoffe und Entsorgung (2018): Recycling braucht verbesserte Mülltrennung. [bvse - Recycling braucht verbesserte Mülltrennung](#) (14.02.2022).
- Burger et al. (2021): Aufkommen und Verwertung von Verpackungsabfällen in Deutschland im Jahr 2019. Umweltbundesamt, Dessau-Roßlau. [Aufkommen und Verwertung von Verpackungsabfällen in Deutschland im Jahr 2019 | Umweltbundesamt](#) (13.02.2023).
- Cat-Krause et al. (2021): Verpackungen im Ressourcenkreislauf: Politikempfehlungen zur Einbindung von Verbraucher:innen bei der Kreislaufführung von Verpackungen. Vorschläge des Clubs für nachhaltige Verpackungslösungen. [CIAP Politikempfehlungen.pdf \(cscp.org\)](#) (27.02.2023).
- Cayé, Nicolas; Leighty, Anke (2019): Bundesweite Erhebung von Daten zum Verbrauch von Getränken in Mehrweggetränkeverpackungen. Bezugsjahr 2019. Umweltbundesamt, Dessau-Roßlau. https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2021-08-04_texte_116-2021_mehrweggetraenkeverpackungen_2019.pdf (14.06.2022).
- Devaney, Laura; Davies, Anna R. (2017): Disrupting household food consumption through experimental HomeLabs: outcomes, connections, contexts. In Journal of Consumer Culture 17(3). pp. 823-844. <https://doi.org/10.1177%2F1469540516631153>.
- European Parliament (2018): Directive 2008/98/EC of the European Parliament and Counsel of 19 November 2008 on waste and repealing certain Directives. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02008L0098-20180705&from=DE> (14.02.2023).
- Fuentes, Christian; Enarsson, Petronella; Kristoffersson, Love (2019): Unpacking package free shopping: alternative retailing and the reinvention of the practice of shopping. Journal of Retailing and Consumer Services 50. pp. 258-265. <https://doi.org/10.1016/j.jretconser.2019.05.016>.
- ifeu (2021): Ökobilanzielle Expertisen zu verschiedenen Lebensmittelverpackungen im Auftrag des Naturschutzbundes Deutschland e.V. Heidelberg: Institut für Energie- und Umweltforschung. https://www.nabu.de/imperia/md/content/nabude/konsumressourcenmuell/211025-ifeu_bericht_nabu_packaging-comparisons.pdf (29.06.2022).
- Kaplan Mintz, Keren; Henn, Laura; Kurman, Jenny (2019): What predicts household waste management behaviors? Culture and type of behavior as moderators. In Resources, Conservation and Recycling 145. pp. 11-18. <https://doi.org/10.1016/j.resconrec.2019.01.045>.
- Klug, Katharina; Niemand, Thomas (2021): The lifestyle of sustainability: testing a behavioral measure of precycling. In: Journal of Cleaner Production 297. 126699. <https://doi.org/10.1016/j.jclepro.2021.126699>.
- Laakso et al. (2021): The role of practice-based interventions in energy transitions: A framework for identifying types of work to scale up alternative practices. In Energy Research & Social Science 72. 101861. <https://doi.org/10.1016/j.erss.2020.101861>.
- Senate Department for the Environment, Mobility, Consumer and Climate Protection (2019): https://www.berlin.de/sen/uvk/assets/environment/environmental-cycle-economy/waste-authorities/waste-balances/waste-balance_2019.pdf (08.06.2022)
- Wiefek, Jasmin; Steinhorst, Julia; Beyerl, Katharina (2021): Personal and structural factors that influence individual plastic packaging consumption – Results from focus group discussions with German consumers. In: Cleaner and Responsible Consumption 3. 100022. <https://doi.org/10.1016/j.clrc.2021.100022>.
- Zeiss, Ragna (2018): From Environmental Awareness to Sustainable Practices. A Case of Packaging-Free Shopping. In: Dhiman, Satinder; Marques, Joan: Handbook of Engaged Sustainability. Springer, Cham. pp. 729-754. https://doi.org/10.1007/978-3-319-71312-0_25.