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Disciplines
Computer Sciences | Engineering | Graphics and Human Computer Interfaces

The Distribution of Carried Items in Urban Environments

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Abstract

Virtual heritage architectural and cultural reconstructions may be enhanced by populating the environment with simulated people. There are a number of important human modeling issues to address such as situationally-appropriate clothing, occupations, and behaviors. Our interest here is focused on how people interact with portable items in their environment: namely, whether they are carrying items and what those items are. With an end goal of enabling lifelike, data-driven agent-based populace simulations, we conducted an informal but systematic ethnographic observational study of the items carried by more than 3,000 people in two different urban community environments: an indoor market and an outdoor city plaza. We recorded the number and types of items carried by each person, along with their gender, estimated age category, and whether they were alone or in a group. We performed a basic statistical analysis of the results. There were two highly significant findings: (1) a strong and similar majority of all people carry at least one item (76.63% in the indoor setting and 79.79% in the outdoor setting); and (2) the types and amounts of items carried were highly consistent across the two different environments, implying that the data may be applicable in a wide range of scenarios.

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Introduction

Simulated people can bring higher levels of depth, engagement, and realism to virtual heritage cultural reconstructions. There are a number of important human modeling issues to address when a virtual re-creation of a specific environment is undertaken, such as situationally-appropriate clothing, occupations, and behaviors. Agent-based crowd simulations already serve a wide range of purposes, such as virtual training and evacuation analysis in building environments, recreating ancient cultures, or creating engaging scenes in movies. (See Thalmann & Musse, 2013 and Pelechano, Allbeck, & Badler, 2008 for comprehensive surveys of crowd simulation systems and characteristics). The aesthetics and veracity of any such application depend on the realism of the simulated characters. Crowd simulations are sometimes based on real-world data for steering behaviors, but besides clothing, the characters are usually unencumbered walkers. One of our primary motivations is the creation of a behaviorally-realistic, contemporary urban environment. Our analogous virtual heritage goal is to create an immersive and real-time virtual reality experience of other historic urban spaces populated with plausible human-like agents.

This paper is focused on two aspects of how people interact with portable items in their environment: whether they are carrying items and what those items are. We want to establish a baseline for contemporary environments, as today's context is tomorrow's heritage. Cultural norms change greatly over time: cell phone use was rare only a decade or two ago; today, it is nearly ubiquitous. Perhaps in another decade unobtrusive wearables will be standard. This investigation is relevant for virtual heritage simulations because personal accouterments help define an agent's mission, completed objectives, status, and occupation.

To enable the creation of lifelike, data-driven, agent-based populace simulations, we conducted an informal but systematic ethnographic study to observe, discover and catalog what items people carry in public spaces. We observed more than 3,000 people in two

different real-life community environments: an indoor market and an outdoor city plaza. We recorded the number and types of items carried by each person, along with contextual factors such as their gender, estimated age, and whether they were alone or in a group. We followed conventional ethological observation practice (*e.g.*, see Baxter, 1970) to minimize contamination of the data that would possibly occur if people knew they were being observed.

Our study focused on three research questions:

- What sorts of items did people carry in a given environment?
- What were the statistical distributions of these items over the observation periods?
- How did these distributions vary across two different urban environments (one indoor and the other outdoor)?

Such data could inform computer graphics modeling of populated environments. Moreover, although we knew that carrying items was an important human characteristic, we had no resource to guide the selection or distribution mechanism. Making random choices over some unknown set of items seemed to be too simple, or perhaps even just wrong. We also wondered how the environment influenced such distributions. Clearly the sorts of activities that occur in different places would vary (*e.g.*, see Parkes & Thrift, 1980), but we found little insights into the actual visible possessions of the people involved.

This paper is organized as follows. First we examine relevant computer graphics crowd animation work. Then we describe our ethological observation methodology and list the items and contextual factors we considered. We present our results in graphical forms, with tables located at the end of the article. We conclude with observations of useful patterns and their consequences for urban crowd simulations.

Related Work

Although interest in crowd simulation systems has grown dramatically, in nearly all cases where identifiable characters or virtual people are being animated, few include agents

actually holding things. There are notable exceptions for specific purposes. For example, games or movies with clashing armies depend on individuals possessing appropriate weaponry. Period or historic settings may include characters wearing or carrying culturally-appropriate items such as swords or headgear. When simulating contemporary crowd scenes in urban settings, however, these particular character accompaniments are inappropriate. Developers of Grand Theft Auto 5 (GTA5) did include a remarkable level of urban character modeling; for instance, non-player characters may photograph the player's shocking actions with their carried cell phones. However, most of the modeling in GTA5 only applies in the extreme, exaggerated fictional world where the game takes place.

There are animation techniques that adapt a character's motion to a carried item, such as a briefcase (Liu, Hertzmann, & Popović, 2005), or extend a character's movement repertoire by combining locomotion with a separately generated upper-body motion (Heck, Kovar, & Gleicher, 2006). In Sung, Kovar, & Gleicher (2005), characters select and carry a box while executing path planning. Sun *et al.* (2012) note that people may be using cellphones when they are engaged in conversations even while walking. Situations involving hostilities using *resources* such as stones and tear gas cannisters are modeled in CrowdMAGS (Moulin & Larochelle, 2010). While having a character possess various resources (its "inventory") is common in games and simulations, the portrayal of these items on a realistic body model is best exemplified by the approach to *accessories* in Maïm, Yersin, & Thalmann (2009). Accessories can range from small detail items such as watches or glasses to clothing options such as hats, or even to larger goods such as backpacks. Their system focuses on the placement of these items onto the body rig and efficient graphics display of the varied appearances. Our interest was piqued by the unknown distribution of carried items in a "typical" urban setting. If we could obtain such data, existing computer animation techniques such as those in Maïm, Yersin, & Thalmann (2009), Bogdanovych *et al.* (2010), or Liu, Hertzmann, & Popović (2005) could be exploited for crowd simulation realism.

Methodology

Manual data collection was performed on-site by a team of three researchers. In the following section, we describe the components and methods of our observational study. We begin by presenting and describing the two real-life community environments where observations took place. Next, we describe how target items were selected and provide the final list of target items. We then propose a list of features of interest: categorical descriptors of observed individuals. Finally, we describe the procedure used to collect and record carried item data.

Environments

Observation sessions were conducted in two contrasting environments. Both environments are located in the city center of Philadelphia. The city of Philadelphia is diverse, urban, and large: at the time of writing, it is the fifth most populous city in the US. In the 2013 United States Census, the racial makeup of Philadelphia was 36.3% Non-Hispanic White, 44.2% Black or African American, 0.8% Native American and Alaska active, 6.9%Asian, 0.1& Native Hawaiian and Other Pacific Islander, 2.4% Two or More Races, and 13.3% Hispanic or Latino.

The first environment was a vast indoor market, which we will refer to as the "Indoor Market". The market layout consists of a grid of vendor stalls, selling a wide range of items: ready-to-eat meals, produce, spices, *etc.* At the market's center is a large dining area. Visitors to the market often go to eat lunch or to shop for items to take home. The second environment was an outdoor plaza in a popular shopping area of the city, which we will refer to as the "City Plaza". The plaza contains a fountain at its center, with many outgoing paths lined with benches. Pedestrians in the plaza are often simply passing through, but sometimes visit with a clear intention: reading, playing an instrument, walking a dog, *etc.*

Observations in both environments were completed during the summer (late June

and early July) of 2014. This is important to note, as weather conditions certainly influence the sorts of items people carry, as well as their behaviors (one is less likely to play an instrument outside in the winter). Research at the Indoor Market was conducted by chance on a rainy day, while the City Plaza observations took place in sunny weather. This explains the presence of umbrellas in the Indoor Market but not the City Plaza. In both locations, observations were completed during the afternoon (between 11:30 AM and 3 PM in the Market, and between 12:30 PM and 4:30 PM in the Plaza).

Both environments are cultural centers that attract large numbers of people every day. However, the environments contrast both in physical characteristics and in function. The Indoor Market is enclosed and often crowded; the City Plaza is outside and open. Visitors to the Indoor Market typically have behaviors and goals specific to the environment: they visit primarily with the intent to purchase food or items. In contrast, visitors to the City Plaza may not directly interact with the environment, and may have unrelated end-goals.

Item List

For the purposes of this study, we define a "carried item" to be any item that a person carries with or on his or her body. The item must be visible to the observer: for example, though we can probably assume most purses contain wallets, a person seen holding only a purse would not be counted towards the Wallet category. The item must also have plausible impact on a person's motion or behavior. Thus, items are not constrained to just what is held in one's hands. Purses and messenger bags leave a person hands-free, but still affect a person's gait. Wearing headphones generally does not affect the specifics of a person's motion, but may influence how a person interacts with the environment and others nearby. To an extent these decisions were subjective; for example, we did not include Glasses as a valid carried item as they are unlikely to meet the impact requirement. We additionally decided that differentiating between types of clothing or

shoes was outside the scope of this project.

We compiled a list of commonly carried items based on observation. Following a short, informal observation session (in which no data was recorded, and observers simply listed all the different items they saw), we proposed an initial list of common items. Additional items were added dynamically throughout subsequent observation sessions. Any item seen was recorded, but only items that occurred at least 5 times were included in the final list. Items occurring fewer than 5 times were simply categorized "Other". Finally, a "Nothing" option was included for people who were not visibly carrying any items. "Nothing" is the only exclusive option: while a person could be encoded with any number of other items at the same time, a person encoded with "Nothing" cannot have any other options encoded.

The complete item list has 21 options:

- Phone *(Both holding to ear while talking, or simply holding in hand)*
- Wallet
- Food - Eating *(For example, holding and eating ice cream cones)*
- Food - Carrying *(Includes boxes and plates of food)*
- Beverage
- Purse
- Headphones
- Shoppings bag(s)
- Backpack
- Stroller
- Umbrella
- Messenger Bag
- Paper Items *(Includes maps, books, papers, etc.)*
- Dog *(Includes holding dog or holding leash)*
- Cigarette

- Child
- Bike *(Riding on bike or walking with bike; also includes scooters, tricycles, etc.)*
- Camera *(Holding in hand or wearing around neck)*
- Musical Instrument
- Other
- Nothing

Four items were added only after visiting the City Plaza, and did not occur in the Indoor Market: Dog, Cigarette, Bike, and Instrument. One item (Umbrella) was observed in the Indoor Market but not the City Plaza.

Features

In addition to items carried, we encoded several features of observed people including gender, estimated age, and group status. Gender encoding was generally straightforward, with options for Male or Female. To estimate age, we classified people into one of five age groups:

- Child *(15 years and under)*
- Young Adult *(16-25 years)*
- Adult *(26-40 years)*
- Middle-Aged *(41-65 years)*
- Senior *(66 years and above)*

Finally, an observed person's *Group Status* was marked *Group* if they were traveling with at least one other person, or *Single* if traveling alone.

Procedure

Data was manually collected on-site using systematic sampling and encoding. Within each environment, the three researchers each observed different sections to avoid duplicate data. Each researcher followed the same procedure: the researcher was seated at a

nondescript location within a heavily traveled area. In the Indoor Market, observers sat at tables in the large dining area. In the City Plaza, observers sat on benches near the center of the plaza. An observation area was chosen, with unambiguous entry and exit points (for example, a person could be considered inside the observation area once they had walked past the right edge of a particular shopping stall). Of the people who entered the observation area, every nth person was recorded, where n varied with the crowd density of each location. In the Indoor Market, every third person was recorded; in the more sparsely populated City Plaza, every second person was recorded. When groups of people entered the observation area together, people were consistently counted from the observer's left.

Once a person was selected for observation, he or she was encoded according to the target features: the researcher subjectively classified the candidate by gender, age group, and group status. Finally, any visible items the person carried were recorded. The overall encodings were recorded in notebooks. For example, a middle-aged female who passed by alone and carried a purse and a beverage would be encoded: "FMS56". After a significant number of data points were collected, the results were aggregated and counted using Python scripts.

Results

Counts of Items by Type

The raw observation data is in the form of counts. All referenced tables are collected together at the end of the article. Table 1 lists the total counts per item type in each environment. Table 2 lists counts in the Indoor Market environment by gender, age, and group status. Table 3 lists counts in the City Plaza by gender, age, and group status. Note that the total counts here are not equal to the total number of people observed because each person can carry any number of items.

Carrying Percentages

From the raw counts, we calculated carrying percentages for each type of item and for each classification. This representation of the data gives a better idea of what items are most common in the overall populations and within each group. In the provided tables, a percentage p for item i and feature f implies that in the population of people with feature f, p percent carry item i.

Table 4 lists the percentages by group in the Indoor Market. Table 5 lists the percentages by group in the City Plaza.

Comparison of Carrying Percentages. Percentages additionally allow for easy comparison between the two environments. Table 6 and Figure 1 display and compare the overall carrying percentages in each environment.

In Figure 1, we see that the overall graph shape is roughly symmetric. Five out of the 21 items only occurred in one environment: Dogs, Cigarettes, Bikes, and Instruments occurred only in the City Plaza, while Umbrellas occurred only in the Indoor Market. The first four are clearly affected by the indoor/outdoor nature of the environments; these items would not make sense in an indoor environment. In contrast, the presence or absence of Umbrellas is likely influenced by external factors (i.e., the weather that day), and not inherent features of the specific environment. This is evident given that umbrellas were carried at the Market on a rainy day, despite the fact that the Market is indoor.

Number of Carried Items Per Person

An important research consideration is that people are typically not limited to carrying a single item. In addition to looking at *what* items people carried, we also observed *how many* items they carried. The number of items ranged from 0 to 5 in the Indoor Market (Tables 7 and 8), and from 0 to 4 in the City Plaza (Tables 9 and 10). Basic statistics were calculated to compare between and within environment populations. The mean number of items carried for each group within each environment are displayed in

Figure 2.

Demographics

The two environments had nearly identical makeups by gender and age, with some variation in group status (Table 12). Predictably, both populations were split nearly in half by gender; men held a very slight majority in each. Age distributions were roughly bell shaped, with the greatest number of people falling into the *Adult* category (Figures 3 and 4).

The most significant environmental difference occurred for the Group Status feature. A slightly larger proportion of visitors to the City Plaza were traveling in groups (60.70% in City Plaza versus 52.90% in Indoor Market). However, both environments saw a majority of people traveling in groups.

Discussion and Analysis

In total, we observed 3060 people: 1713 in the Indoor Market, and 1347 in the City Plaza. This thorough and systematic observation yielded data that is of high merit in its own right. Yet, the most profound value is found in the patterns that emerge from the data. There are core findings that provide insight into the nature of crowds and cultural environments, and guidance for their simulation in virtual heritage applications.

Influence of Character Features

Character features were found to impact both the types and numbers of items carried. Age, Gender, and Group Status all appeared to influence some results, some stronger than others. Such differences could be built into virtual environments for generating virtual characters; for instance, simulations could employ a probabilistic model based on these or other collected datasets to determine the items a character tagged with one or more features should carry. Characters' carried items could in turn influence their gait or possible actions. For instance, a person carrying a heavy shopping bag might

change his or her gait to compensate the weight, or a person carrying a wallet may be more likely to stop and purchase an item. A person carrying and using a phone may be less attentive to surroundings and be more lax in collision avoidance strategies. Items carried may influence personal space, either increasing it with bulky items or even decreasing it by limiting a hallmark of unencumbered walking, the arm swing. Thus, the simple, data-driven addition of carried items could facilitate the creation of virtual environments with more variety, complexity, and realism. In this section, we will discuss some of the stronger emergent patterns of each feature.

Gender strongly influences the number of items a person carries. In general, women carry more items than men: women carried 56.43% more items than men in the Indoor Market, and 65.28% more items than men in the City Plaza. More insight is gained by looking at the gender differences for specific items.

Although women carry more items overall, it is not true that women carry each individual item more often; in fact, men and women were nearly balanced in this consideration (as seen in Table 13). However, the items carried more by women are also the most common items overall; in contrast, men tended to carry more obscure items at higher rates.

Age group similarly influences the number of items held. In Tables 4 and 6, we see the mean of items carried is significantly lower for children and seniors. Additionally, the mean for people in groups is lower than those who are traveling singly. Together, these results might imply that people within a group may carry items for children or seniors in the group. Though we did not consider interactions between features in this study, there is compelling reason to investigate them further.

Stability Across Multiple Environments

The patterns of variation by feature are validated by their recurrence across both environments. Despite core differences in the environments, these patterns were

remarkably similar. Carrying rates for particular item types did have some moderate differences. These differences make intuitive sense: for instance, Beverages were carried at higher rates in the Indoor Market, where stalls often sell specialty beverages. However, in most cases the *patterns* of these rates are similar in both environments. In Figure 5, we see the carrying rates of Shopping Bags. They are carried at higher rates in general in the Indoor Market, but the differences between groups within each environment are similar.

Despite some item-specific differences, general rates of item carrying were highly similar, as evident in Table 11. In both environments women have the highest mean items carried, while children have the lowest. Differences of the means of each group between the environments were generally quite small: the largest difference was 0.2186 for the Child group, the smallest difference was 0.0087 for the Adult group, and the average difference was 0.113. To determine whether the overall means in each environment were statistically different, we performed a Two-Tailed T-Test with 3058 degrees of freedom. The difference was not significant, even for high values of p ($p < .2$).

Similarities in data collected from two contrasting environments suggest that the results may be extensible to a wider range of environments, but this remains for future work.

Prevalence of Carried Items

The most fundamental conclusion is that carried items are ubiquitous in real-world environments. In general, the large majority of people carry *something*. Across our entire sampling, only 21.93% of people (about 1 in 5) did not carry any items (Figure 6). This result was consistent across environments and features. Of the 18 different categorizations (9 in each location), only one (Children in the City Plaza) had a majority of members carrying nothing.

These results imply that a simulated crowd in any general urban virtual environment will be a more accurate representation of real life if it includes carried items. To achieve

realism, a large majority of animated agents ought to be shown carrying things, especially from amongst the set of items we enumerated.

Conclusion

This informal ethological study began with the hypothesis that people in public spaces often carried items. By understanding the kinds, frequencies of occurrence, and feature correlations of such items, perhaps the communities of non-player characters ("NPCs") in games, simulations, or historic reconstructions could be made to resemble more closely their real-life counterparts. After concerted observations in both Indoor Market and City Plaza environments we found that our hypothesis was valid and that useful and coherent relationships were discoverable in the sample data. While we cannot claim any universality for our item distributions, these can be a realistic starting point for the simulation of customized urban environments. Our methodology poses a set of relevant questions and general answers about personal items that could be present and meaningful in re-populated virtual heritage reconstructions.

One way such information could be used is to further inform the goal-directed activities of an agent encumbered with a particular item. For example, possessing a full shopping bag may bias an NPC to head for home rather than go to a park. Such activity hints could be exploited in the "alibi generation" technique described by Sunshine-Hill & Badler (2010). Rather than have NPCs wander aimlessly, when observed over a period of time, an NPC acquires a statistically meaningful goal and thus an "alibi" to follow a path to that goal. We expect that assigning meaningful behaviors to an NPC that bear some relationship to its carried items – and *vice versa* – is a necessary next step in crowd simulation.

For virtual heritage populace simulations, the presence and types of carried items likewise can be important visual cues to agent behaviors. Historical sites, documented from photographs for example, could be examined for accessory types and occurrences. More

indirect evidence for human behavior may be gleaned from item assemblages found in archaeological contexts, such as tools, weapons, musical instruments, agricultural implements, personal ornamentation, and drinking and eating vessels. Many of these items are made to be portable and transporting them would be part of everyday life as well as ceremonial events.

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Table 1
Total item counts in each environment

Item	Indoor Market	City Plaza
Phone	129	181
Wallet	50	14
Food [Eating]	16	20
Food [Carrying]	174	32
Beverage	370	176
Purse	491	465
Headphones	31	79
Shopping Bags	285	170
Backpack	187	137
Stroller	22	48
Umbrella	26	0
Messenger Bag	81	72
Paper Items	30	44
Dog	0	47
Cigarette	0	10
Child	4	9
Bike	0	40
Camera	12	12
Instrument	0	7
Other	49	41
Nothing	399	272

Table 2
Item counts in Indoor Market.

Item	Male	Female	Child	Young Adult	Adult	Middle-Aged	Senior	Group	Single
Phone	57	72	2	35	76	14	2	42	87
Wallet	7	43	1	12	27	7	3	24	26
Food [Eating]	4	12	1	6	5	3	1	8	8
Food [Carrying]	88	86	3	35	88	35	13	89	85
Beverage	194	176	15	69	181	73	32	211	159
Purse	20	471	1	100	189	136	65	256	235
Headphones	21	10	0	17	12	2	0	4	27
Shopping Bags	139	146	7	34	122	63	59	106	179
Backpack	120	67	15	40	94	31	7	96	91
Stroller	13	9	0	1	16	3	2	18	4
Umbrella	12	14	0	0	8	15	3	10	16
Messenger Bag	42	39	0	12	38	19	12	41	40
Paper Items	25	5	1	3	15	6	5	16	14
Dog	0	0	0	0	0	0	0	0	0
Cigarette	0	0	0	0	0	0	0	0	0
Child	1	3	0	1	3	0	0	3	1
Bike	0	0	0	0	0	0	0	0	0
Camera	7	5	0	3	3	3	3	11	1
Instrument	0	0	0	0	0	0	0	0	0
Other	27	22	6	2	18	10	13	21	28
Nothing	335	64	39	59	155	100	46	227	172

Table 3
Item counts in City Plaza.

Item	Male	Female	Child	Young Adult	Adult	Middle-Aged	Senior	Group	Single
Phone	92	89	1	58	87	30	5	74	107
Wallet	1	13	0	3	9	1	1	8	6
Food [Eating]	8	12	0	4	8	5	3	13	7
Food [Carrying]	20	12	0	8	17	4	3	21	11
Beverage	90	86	2	37	105	26	6	110	66
Purse	8	457	1	127	217	89	31	295	170
Headphones	51	28	0	26	46	7	0	1	78
Shopping Bags	75	95	1	32	76	40	21	80	90
Backpack	95	42	0	45	68	19	5	60	77
Stroller	21	27	0	1	37	10	0	41	7
Umbrella	0	0	0	0	0	0	0	0	0
Messenger Bag	57	15	0	8	42	19	3	28	44
Paper Items	36	8	2	3	20	11	8	17	27
Dog	29	18	1	8	22	14	2	20	27
Cigarette	10	0	0	2	5	2	1	4	6
Child	5	4	0	0	8	1	0	7	2
Bike	33	7	9	8	17	5	1	19	21
Camera	7	5	0	3	4	4	1	8	4
Instrument	7	0	0	0	7	0	0	1	6
Other	20	21	3	5	14	10	9	20	21
Nothing	233	39	28	38	112	62	32	208	64

Table 4
Carrying percentages in Indoor Market.

Item	Male	Female	Child	YA	Adult	Middle-Aged	Senior	Group	Single
Phone	6.22%	9.11%	2.35%	11.59%	10.44%	3.48%	1.05%	4.65%	10.82%
Wallet	0.76%	5.44%	1.18%	3.97%	3.71%	1.74%	1.58%	2.66%	3.23%
Food [Eating]	0.44%	1.52%	1.18%	1.99%	0.69%	0.75%	0.53%	0.89%	1.00%
Food [Carrying]	9.60%	10.89%	3.53%	11.59%	12.09%	8.71%	6.84%	9.86%	10.57%
Beverage	21.16%	22.28%	17.65%	22.85%	24.86%	18.16%	16.84%	23.37%	19.78%
Purse	2.18%	59.62%	1.18%	33.11%	25.96%	33.83%	34.21%	28.35%	29.23%
Headphones	2.29%	1.27%	0.00%	5.63%	1.65%	0.50%	0.00%	0.44%	3.36%
Shopping Bags	15.16%	18.48%	8.24%	11.26%	16.76%	15.67%	31.05%	11.74%	22.26%
Backpack	13.09%	8.48%	17.65%	13.25%	12.91%	7.71%	3.68%	10.63%	11.32%
Stroller	1.42%	1.14%	0.00%	0.33%	2.20%	0.75%	1.05%	1.99%	0.50%
Umbrella	1.31%	1.77%	0.00%	0.00%	1.10%	3.73%	1.58%	1.11%	1.99%
Messenger Bag	4.58%	4.94%	0.00%	3.97%	5.22%	4.73%	6.32%	4.54%	4.98%
Paper Items	2.73%	0.63%	1.18%	0.99%	2.06%	1.49%	2.63%	1.77%	1.74%
Dog	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Cigarette	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Child	0.11%	0.38%	0.00%	0.33%	0.41%	0.00%	0.00%	0.33%	0.12%
Bike	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Camera	0.76%	0.63%	0.00%	0.99%	0.41%	0.75%	1.58%	1.22%	0.12%
Instrument	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Other	2.94%	2.78%	7.06%	0.66%	2.47%	2.49%	6.84%	2.33%	3.48%
Nothing	36.53%	8.10%	45.88%	19.54%	21.29%	24.88%	24.21%	25.14%	21.39%

Table 5
Carrying percentages in City Plaza.

Item Type	Male	Female	Child	YA	Adult	Middle-Aged	Senior	Group	Single
Phone	13.16%	13.76%	2.08%	21.89%	13.24%	11.03%	4.81%	9.06%	20.23%
Wallet	0.14%	2.01%	0.00%	1.13%	1.37%	0.37%	0.96%	0.98%	1.13%
Food [Eating]	1.14%	1.85%	0.00%	1.51%	1.22%	1.84%	2.88%	1.59%	1.32%
Food [Carrying]	2.86%	1.85%	0.00%	3.02%	2.59%	1.47%	2.88%	2.57%	2.08%
Beverage	12.88%	13.29%	4.17%	13.96%	15.98%	9.56%	5.77%	13.46%	12.48%
Purse	1.14%	70.63%	2.08%	47.92%	33.03%	32.72%	29.81%	36.11%	32.14%
Headphones	7.30%	4.33%	0.00%	9.81%	7.00%	2.57%	0.00%	0.12%	14.74%
Shopping Bags	10.73%	14.68%	2.08%	12.08%	11.57%	14.71%	20.19%	9.79%	17.01%
Backpack	13.59%	6.49%	0.00%	16.98%	10.35%	6.99%	4.81%	7.34%	14.56%
Stroller	3.00%	4.17%	0.00%	0.38%	5.63%	3.68%	0.00%	5.02%	1.32%
Umbrella	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Messenger Bag	8.15%	2.32%	0.00%	3.02%	6.39%	6.99%	2.88%	3.43%	8.32%
Paper Items	5.15%	1.24%	4.17%	1.13%	3.04%	4.04%	7.69%	2.08%	5.10%
Dog	4.15%	2.78%	2.08%	3.02%	3.35%	5.15%	1.92%	2.45%	5.10%
Cigarette	1.43%	0.00%	0.00%	0.75%	0.76%	0.74%	0.96%	0.49%	1.13%
Child	0.72%	0.62%	0.00%	0.00%	1.22%	0.37%	0.00%	0.86%	0.38%
Bike	4.72%	1.08%	18.75%	3.02%	2.59%	1.84%	0.96%	2.33%	3.97%
Camera	1.00%	0.77%	0.00%	1.13%	0.61%	1.47%	0.96%	0.98%	0.76%
Instrument	1.00%	0.00%	0.00%	0.00%	1.07%	0.00%	0.00%	0.12%	1.13%
Other	2.86%	3.25%	6.25%	1.89%	2.13%	3.68%	8.65%	2.45%	3.97%
Nothing	33.33%	6.03%	58.33%	14.34%	17.05%	22.79%	30.77%	25.46%	12.10%

Table 6
Carrying percentages in both environments.

Item Type	Indoor Market	City Plaza
Phone	7.56%	13.45%
Wallet	2.93%	1.04%
Food [Eating]	0.94%	1.49%
Food [Carrying]	10.19%	2.38%
Beverage	21.68%	13.08%
Purse	28.76%	34.55%
Headphones	1.82%	5.87%
Shopping Bags	16.70%	12.63%
Backpack	10.95%	10.18%
Stroller	1.29%	3.57%
Umbrella	1.52%	0.00%
Messenger Bag	4.75%	5.35%
Paper Items	1.76%	3.27%
Dog	0.00%	3.49%
Cigarette	0.00%	0.74%
Child	0.23%	0.67%
Bike	0.00%	2.97%
Camera	0.70%	0.89%
Instrument	0.00%	0.52%
Other	2.87%	3.05%
Nothing	23.37%	20.21%

Table 7
Counts per number of items in Indoor Market.

Number of Items	**0**	**1**	**2**	**3**	**4**	**5**
Male	335	420	142	23	1	0
Female	64	374	261	85	7	1
Child	39	40	4	2	0	0
Young Adult	59	137	81	25	2	0
Adult	155	333	179	55	5	1
Middle-Aged	100	198	90	15	1	0
Senior	46	86	49	11	0	0
Group	227	447	190	37	6	0
Single	172	347	213	71	2	1
All	*399*	*794*	*403*	*108*	*8*	*1*

Table 8
Statistics for number of carried items in Indoor Market.

	N	Mean Number of Items	SD
Male	921	0.84365	0.7766
Female	792	1.49495	0.83332
Child	85	0.63529	0.68337
Young Adult	304	1.25658	0.88177
Adult	728	1.21016	0.89477
Middle-Aged	404	1.05693	0.79865
Senior	192	1.13021	0.84084
Group	907	1.06064	0.82389
Single	806	1.23945	0.90270
All	*1713*	*1.14478*	*0.86648*

Table 9
Counts per number of items in City Plaza.

Number of Items	**0**	**1**	**2**	**3**	**4**	**5**
Male	232	313	120	30	4	0
Female	39	342	214	45	7	0
Child	28	20	0	0	0	0
Young Adult	38	116	80	26	5	0
Adult	112	337	167	37	5	0
Middle-Aged	62	135	64	10	1	0
Senior	32	47	23	2	0	0
Group	208	424	161	24	1	0
Single	64	231	173	51	10	0
All	*272*	*655*	*334*	*75*	*11*	*0*

Table 10
Statistics for number of items carried in City Plaza.

	N	Mean Number of Items	SD
Male	700	0.94143	0.85071
Female	647	1.44204	0.75579
Child	48	0.41667	0.49301
Young Adult	265	1.41132	0.91562
Adult	658	1.21884	0.81819
Middle-Aged	272	1.09191	0.79683
Senior	104	0.95192	0.77683
Group	818	1.00489	0.76121
Single	529	1.45558	0.89232
All	*1347*	*1.18189*	*0.84441*

Table 11
Comparison of overall carrying statistics in each environment.

	Indoor Market	City Plaza
N	1713	1347
Mean Number of Items Carried	1.14478	1.18189
Standard Deviation	0.86648	0.84441
Variance	0.75079	0.71302

Table 12
Demographic breakdown of both environments.

	Indoor Market		City Plaza	
	Count	Percentage	Count	Percentage
Female	792	46.23%	647	48.03%
Male	921	53.77%	700	51.97%
Child	85	4.96%	48	3.56%
Young Adult	304	17.75%	265	19.67%
Adult	728	42.50%	658	48.85%
Middle-age	404	23.58%	272	20.19%
Senior	192	11.21%	104	7.72%
Group	907	52.95%	818	60.73%
Single	806	47.05%	529	39.27%
Total people:	**1713**		**1347**	

Table 13
Comparison of items carried more often by each gender.

Carried More by Men		Carried More by Women	
Market	Plaza	Market	Plaza
Headphones	Food [C]	Phone	Phone
Backpack	Headphones	Wallet	Wallet
Stroller	Backpack	Food [E]	Food [E]
Paper Items	Messenger B.	Food [C]	Beverage
Camera	Paper Items	Beverage	Purse
Other	Dog	Purse	Shopping Bags
	Cigarette	Shopping Bags	Stroller
	Child	Umbrella	Other
	Bike	Messenger B.	
	Camera	Child	
	Instrument		

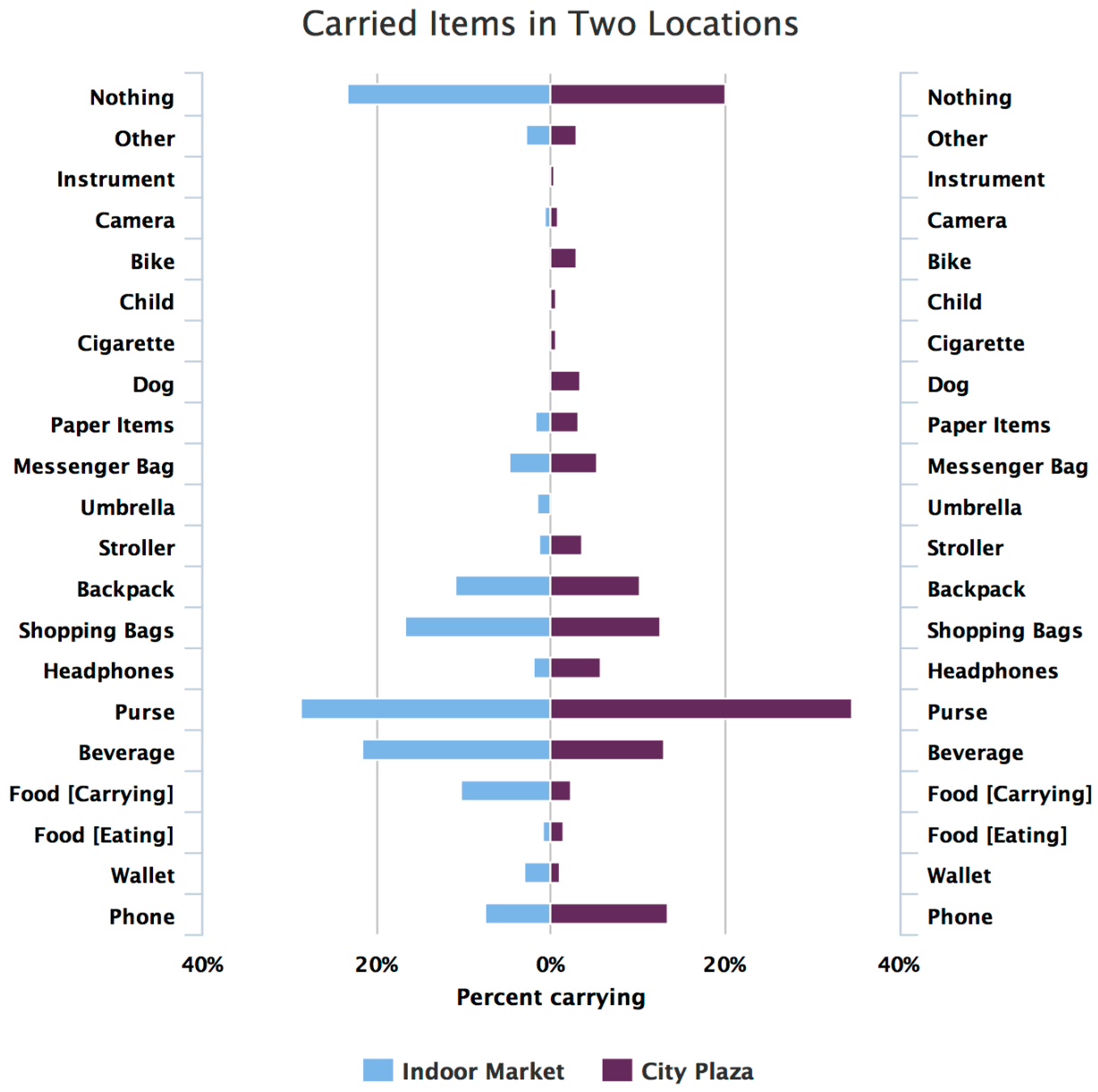

Figure 1. Comparison of carrying percentages.

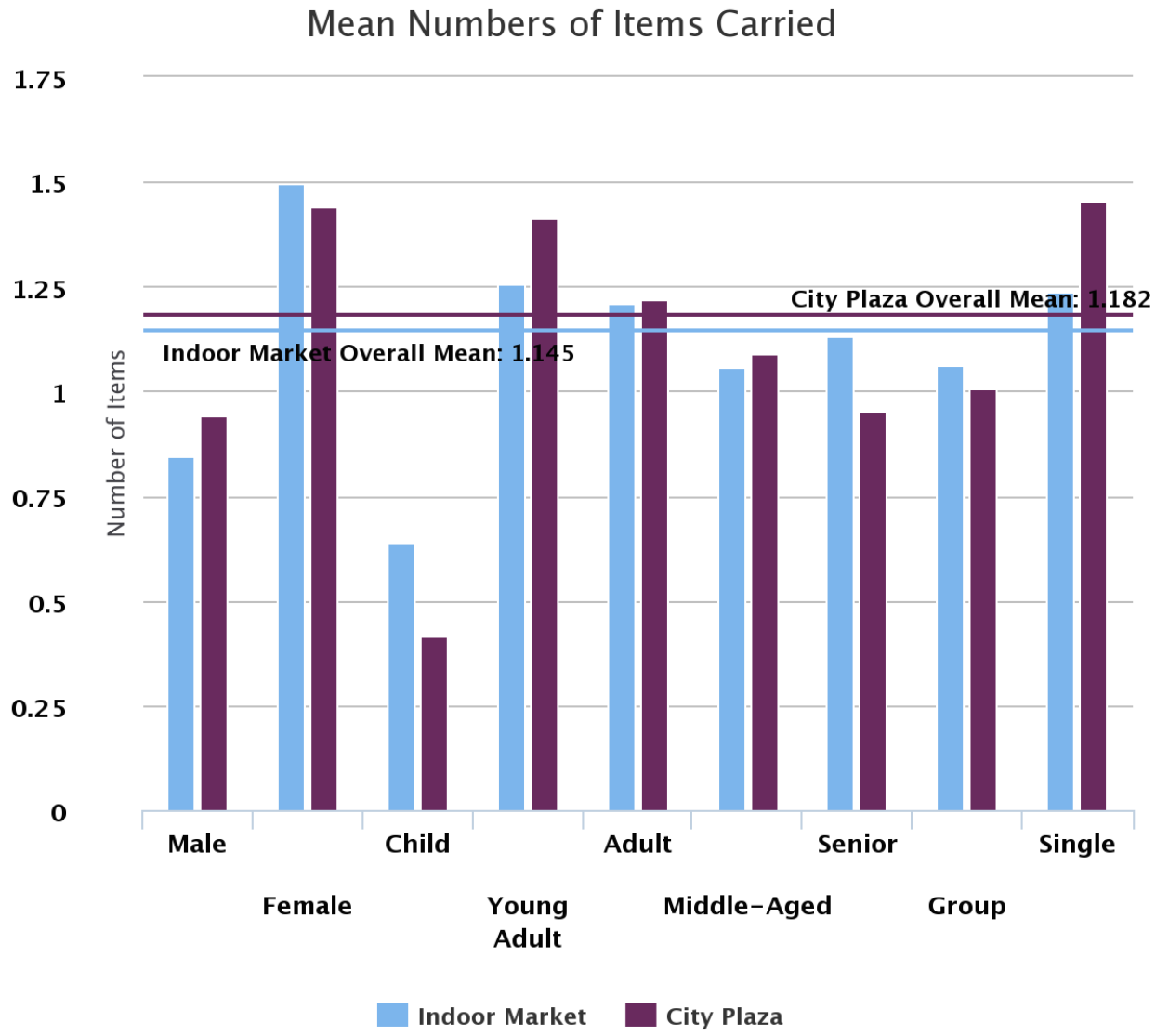

Figure 2. Comparison of mean number of items carried for each group.

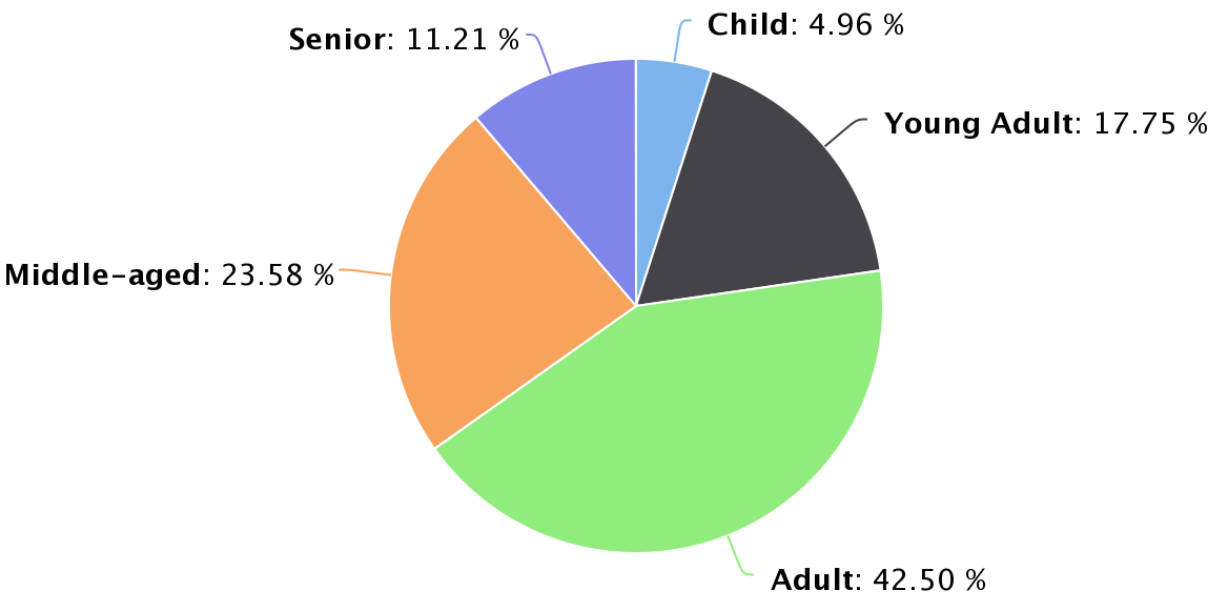

Figure 3. Age distribution in Indoor Market.

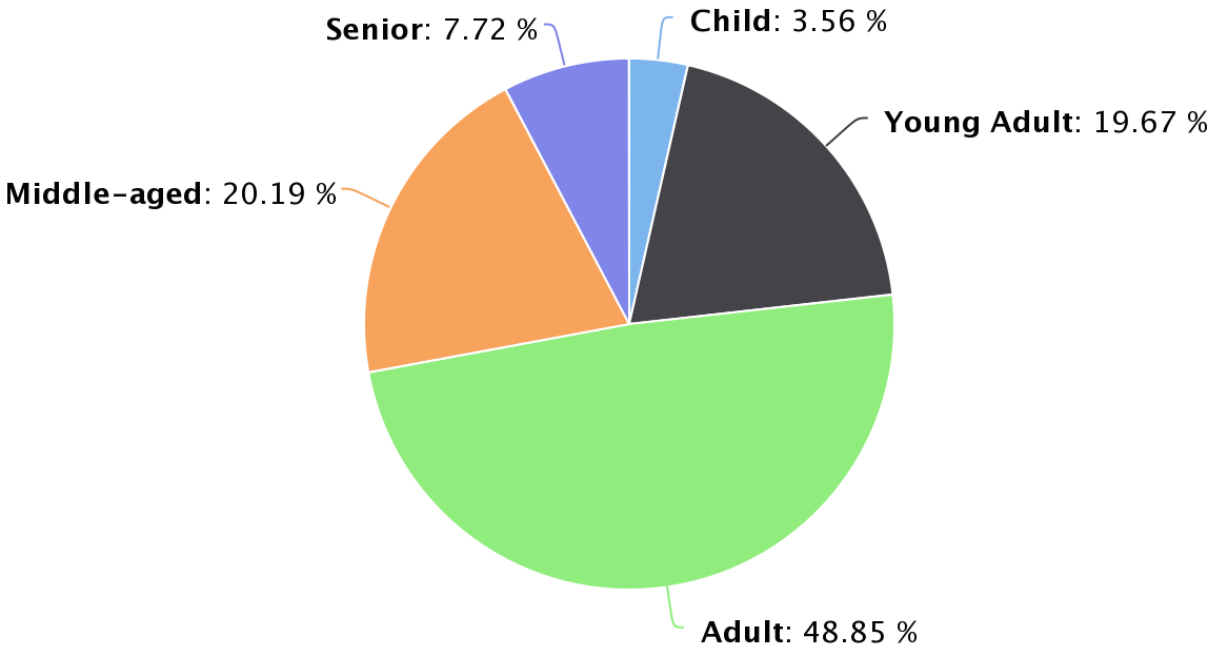

Figure 4. Age distribution in City Plaza.

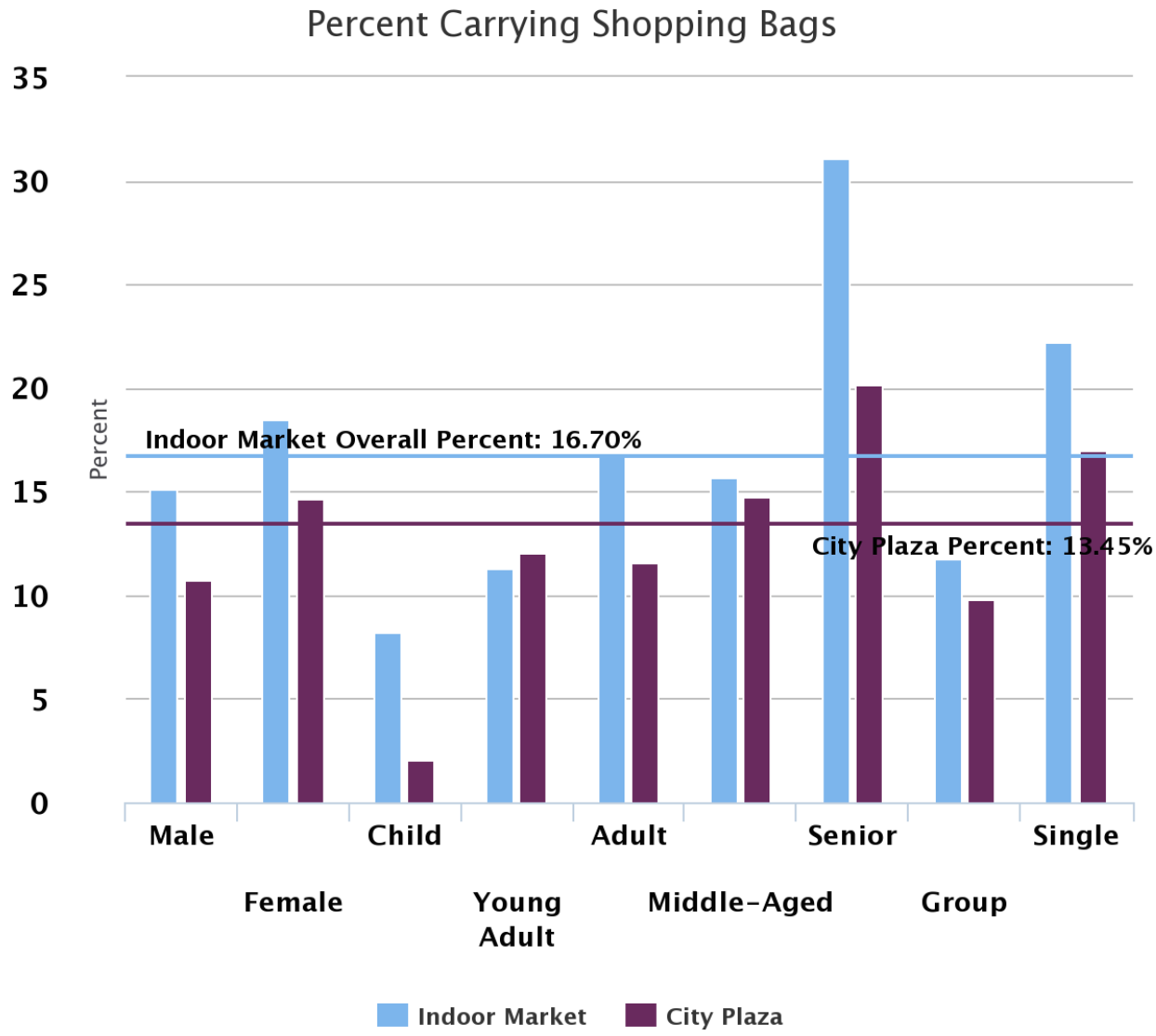

Figure 5. Carrying rates of Shopping Bags in both environments.

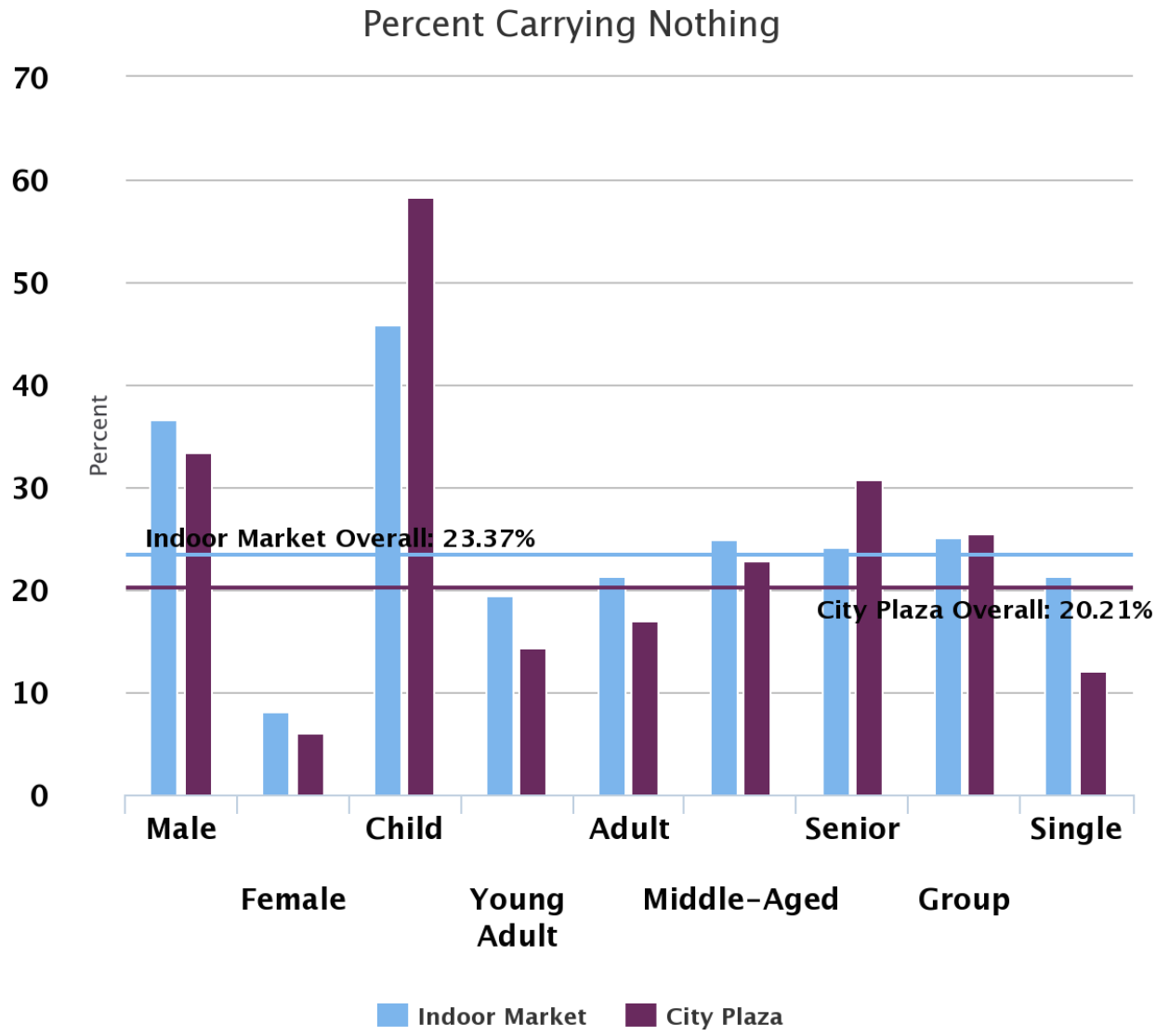

Figure 6. Percent carrying no items in all groups and environments.