Mattress and Foundation Age Analysis

July 2023

Executive Summary

Mattresses and foundations (together referred to as units) are tagged when manufactured and that tag contains a range of identification information such as manufacturer name, address, material content and in most cases, the date manufactured. In 2019, MRC concluded a study to determine the average age of mattresses and foundations discarded at recycling facilities in Rhode Island, Connecticut and California. That study determined based on available tag data the average age of units was 11.2 years and that there was not a significant difference in discarded unit age between the three states. However, that study also observed that only 35% of discarded units contained date tags, meaning that 65% of the units were missing date tags (untagged units) and were excluded from the data set.

In 2022, MRC replicated that 2019 study but added an investigational component to estimate the age of untagged units by approximating the manufacturing date of untagged units using visual and construction type cues including ticking design, flame retardant barrier technology, construction methods and component types. To accomplish this, MRC contracted with two mattress industry veterans with 73 years of combined experience to visually inspect and assign a manufacturing date range to untagged units.

Customer Analytics, LLC analyzed the data to estimate the ages of both tagged and untagged discarded mattresses and foundations in California. At a 95% confidence level, the analysis reveals a mean age of 13.9 ± 0.4 years for all units combined. Among these, tagged units have a mean age of 10.2 ± 0.4 years, while untagged units average 19.7 ± 0.8 years.

The study provides detailed information about the age distribution of mattresses and foundations by reporting the mean age, standard deviation, confidence interval, and histogram for each unit type and tagging status. This comprehensive analysis offers timely insights into understanding the time period between manufacturing date and product discard. The results of this study, however, do not necessarily represent the durability or useful life of mattresses and foundations because a number of factors in addition to whether a unit is worn out that influence a consumer's decision whether to discard a mattress. Likewise, this study does not evaluate the extent to which the average age for all mattress types may be impacted as a result of market share shifts of different mattress construction types in recent years.

Project Overview

Mattresses and foundations (together referred to as units) are tagged when manufactured and that tag contains a range of identification information such as manufacturer name, address, material content and in most cases, the date manufactured. In 2019, MRC concluded a study to determine the average age of mattresses and foundations discarded at recycling facilities in Rhode Island, Connecticut and California. That study determined the average age of units was 11.2 years and that there was not a significant difference in discarded unit age between the three states. However, that study also observed that only 35% of discarded units contained date tags, meaning that 65% of the units were missing date tags (untagged units) and were excluded from the data set.

In 2022, MRC replicated the 2019 study for California but added an investigational component to estimate the age of untagged units by approximating the manufacturing date of untagged units using visual and construction type cues including ticking design, flame retardant barrier technology, construction methods and component types. To accomplish this, MRC contracted with two mattress industry veterans with 73 years of combined experience to visually inspect and assign a manufacturing date range to untagged units.

MRC has an interest in determining the average age of discarded units to:

- Understand the average time between when units are manufactured and discarded in California.
- Predict the average age and composition of units that will be discarded in coming years. This is important for recyclers to anticipate and plan for changes in recycling equipment required to maximize recycling of components and identify end-markets for extracted commodities.

During the research planning phase, MRC determined that approximately 2,000 units were needed to form a representative sample. We estimated that this sample size would yield proportion estimates within 5% of the true population value with a 95% confidence level.

Data Collection Summary

Over a period of several days in November 2022, MRC organized a team that collected data for the study and documented information from 1,847 tagged and untagged units that arrived during the study period. These units appear in the data in three categories:

1. Innerspring spring mattresses – Mattress units that contain an open metal coil spring layer or a pocketed spring coil (individual metal coils encased in fabric sleeves) layer.
2. All foam mattresses – Mattress units that do not contain any metal coils. All foam units may be constructed of all polyurethane foam, latex foam or a combination of foam types with other support layers.

3. Foundations – Commonly called box springs, these are fabric covered frames used to support a mattress. Foundations are typically constructed of wood frames that may or may not include a metal support structure.

Units selected for the study originated from the most common sources of residential units discarded in California including solid waste facilities (transfer stations and landfills), community mattress collection events and retailers that take back old units from consumers when they deliver a new one. Large homogeneous loads from sources like hotels and universities represent a very small percentage of MRC's sources and were excluded to not affect the data set.

For tagged units, the manufacturing year, and in some cases, the month or exact date, were recorded. For untagged units, the on-site mattress industry experts estimated the production year ranges by assigning an estimated manufacturing date, +/- 3 years. Additionally, unit type information was documented. This comprehensive data collection approach provided a representative sample, encompassing diverse types and dates providing opportunities for accurate estimates with a high degree of confidence.

Treatment of Exact-Valued Ages for Tagged Units

The analysis takes into account the varying degrees of specificity in the age data for tagged mattresses and foundations. For those units with the exact manufacturing year, month, and day documented, the precise date is included in the analysis. In cases where only the manufacturing year and month are available, the first day of the specified month is used to approximate the manufacturing date. For units with only the manufacturing year identified, a conservative approach is used by selecting July 1 of that year, representing the midpoint of the year, as the estimated manufacturing date.

Following this treatment, the distribution function $f_{tagged}(x)$ for tagged units is obtained. Using this function, the sample mean, standard deviation, and confidence interval are calculated to provide an overall understanding of the data.

Treatment of Range-Valued Ages for Untagged Units

Regarding untagged units, the goal is to obtain point estimates for the mean and standard deviation of mattress and foundation ages. For untagged units, manufacturing years are presented as ranges. To estimate the mean, the midpoint of each range is used as a representative value. For variance estimation, a mixture distribution approach as outlined below is applied.

Consider a sample of N units. Let n be a mattress or foundation with a manufacturing year range $[a_n, b_n]$. We treat the year of manufacture as a random variable described by the probability density $f_n(x) = 1/(b_n - a_n)$ if $x \in [a_n, b_n]$. To obtain the distribution of the manufacturing years/ages for the entire sample, we aggregate the densities, or "weights", for each $n = 1,2, \ldots, N$ along the year/age axis and standardize them by dividing the sum by N. This aggregate density function, denoted as $f_{untagged}(x)$, resembles a histogram, as illustrated in Figure 1.

From this distribution, we can calculate the sample mean $\bar{x} = \int x f_{untagged}(x)dx$, which corresponds to taking midpoints, and the sample variance $s^2 = \int x^2 f_{untagged}(x)dx - \bar{x}^2$, which more accurately reflects the uncertainties in range values compared to merely using midpoints. We leverage the central limit theorem[1] to determine the confidence interval. As a robustness check, we also use bootstrapping[2] to construct the confidence interval considering that this distribution is non-standard and complex. In the unlikely event that the sample size is not large enough for the sampling distribution to quickly converge to normal, this method would improve accuracy.

Figure 1: Example of Mixture Distribution Approach to Range-valued Ages

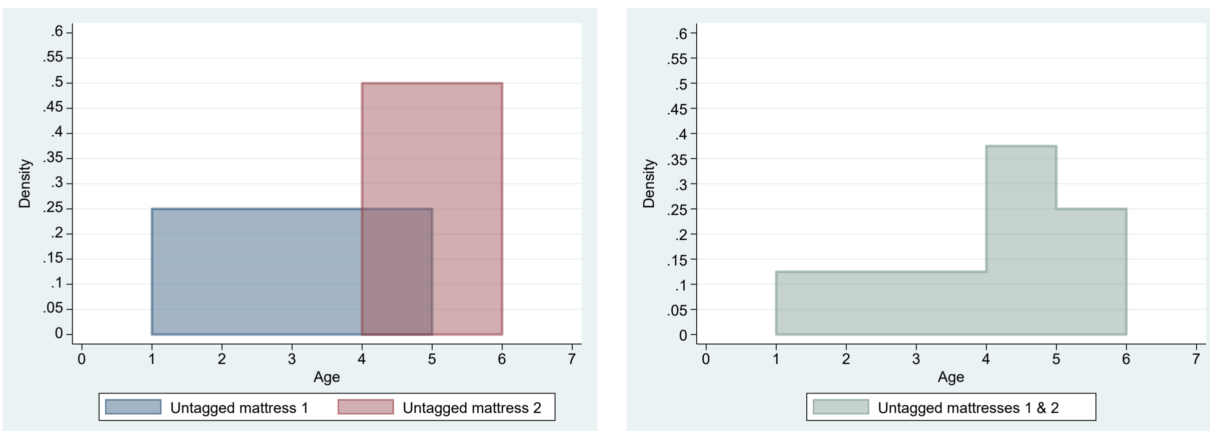

Figure 1A: Individual densities for two untagged mattresses whose age ranges are [1, 5] and [4, 6]

Figure 1B: Aggregate densities for the two untagged mattresses after standardization

Combining Tagged and Untagged Units

We combine the distributions of both tagged and untagged mattresses and foundations by employing the mixture distribution approach one more time. Let p be the proportion of tagged units and $1 - p$ the proportion of untagged units. The combined distribution function that describes the mixture is given by:

$$f_{combined}(x) = p \times f_{tagged}(x) + (1 - p) \times f_{untagged}(x)$$

[1] The central limit theorem states that the distribution of the sample mean approaches a normal distribution as the sample size becomes larger, regardless of the distribution shape of underlying data.
[2] Bootstrapping is a resampling technique that involves generating a large number of resamples from the original data with replacement, calculating the statistic of interest for each resample, and then using the distribution of these resampled statistics to estimate the confidence interval.

This combined distribution incorporates information from both tagged and untagged mattresses, appropriately weighted based on their proportion in the sample. From this combined distribution, we can then calculate relevant statistics such as the mean, standard deviation, and confidence interval for the sample, providing a comprehensive analysis of the mattress and foundation ages.

Exclusion of Outliers

To minimize the potential impact from outliers, such as extremely old mattresses that deviate from the norm, the analysis uses a robust method for detecting and excluding these outliers based on the interquartile range (IQR). The IQR is calculated as the difference between the first quartile (Q1) and the third quartile (Q3) of a given distribution. The standard approach for identifying outliers is based on the following bounds:

- Lower bound = Q1 – 1.5 × IQR
- Upper bound = Q3 + 1.5 × IQR

Observations below the lower bound or above the upper bound are deemed outliers and subsequently excluded from further analysis. Following the exclusion of these outliers, the distribution functions are re-standardized so that their sum/integral over the sample space equals one. This approach ensures the integrity of the analysis by minimizing the influence of extreme values on the mean and variance estimates.

Findings

Of the initial 1,847 observations, 1,793 have remained after excluding outliers and unknown unit types. Innerspring (IS) and All-Foam (AF) mattresses represent 64.3 percent of the data points, with Foundations (F) representing the other 35.7 percent. The frequency distribution for each category is shown in Table 2.

Table 2: Frequency Distribution by Category

	Tagged	Untagged	Combined
Innerspring Mattress (IS)	585 (32.6%)	386 (21.5%)	971 (54.1%)
All-Foam Mattress (AF)	132 (7.4%)	50 (2.8%)	182 (10.2%)
Foundation (F)	376 (21.0%)	264 (14.7%)	640 (35.7%)
All Unit Types	1,093 (61.0%)	700 (39.0%)	**1,793** **(100%)**

We report the mean statistics for each category in Table 3. The age is calculated by first taking the difference in days between the manufacturing date and the first observation date (November 1, 2022) and then converting the number of days into the number of years.

Table 3: Mean Age and Manufacture Date by Category

	Tagged	Untagged	Combined
All Mattresses (IS + AF)	9.8 years (January 2013)	18.9 years (November 2003)	13.2 years (August 2009)
Foundation (F)	11.0 years (October 2011)	20.9 years (November 2001)	15.1 years (September 2007)
All Unit Types	10.2 years (August 2012)	19.7 years (February 2003)	**13.9 years (November 2008)**

To assess the variability and dispersion of the ages in relation to the mean, we report the standard deviation, which can be found in Table 4 for each corresponding category.

Table 4: Standard Deviation of Age by Category

	Tagged	Untagged	Combined
All Mattresses (IS + AF)	6.5 years	10.5 years	9.4 years
Foundation (F)	6.6 years	11.1 years	10.0 years
All Unit Types	6.5 years	10.8 years	**9.7 years**

Given the mean and standard deviation, we use the central limit theorem[3] to compute the confidence interval, which provides a range where the true population mean is likely to be found, with a standard 95% level of confidence. Refer to Table 5 for details.

Table 5: Mean Age with 95% Confidence Interval by Category

	Tagged	Untagged	Combined
All Mattresses (IS + AF)	9.8 ± 0.5 years	18.9 ± 1.0 years	13.2 ± 0.6 years
Foundation (F)	11.0 ± 0.7 years	20.9 ± 1.3 years	15.1 ± 0.8 years
All Unit Types	10.2 ± 0.4 years	19.7 ± 0.8 years	**13.9 ± 0.4 years**

At the conventional 0.05 level, a t-test reveals a statistically significant age difference Mattresses (IS+AF) and Foundations (F). A separate t-test also shows a significant age difference when comparing tagged and untagged units.

Finally, the age distribution for each category using histograms is presented. These graphical representations offer a more comprehensive view of the data, such as the distribution range and shape, in addition to the summary statistics above.

[3] Bootstrapping is used as a robustness check, achieving similar results. Therefore, only the results obtained from the central limit theorem are reported.

Figure 2: Histogram of Age by Category

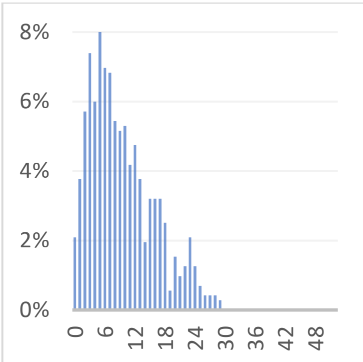

Figure 2A: All Mattresses-Tagged

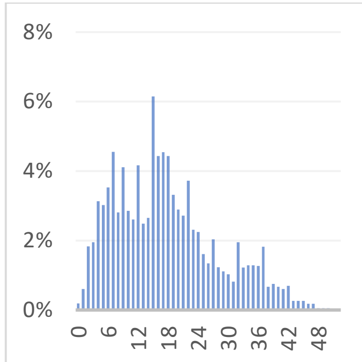

Figure 2B: All Mattresses-Untagged

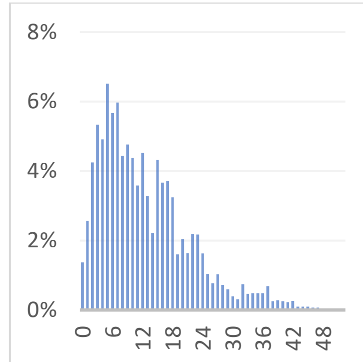

Figure 2C: All Mattresses-Combined

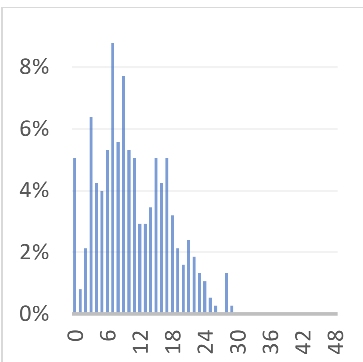

Figure 2D: Foundations-Tagged

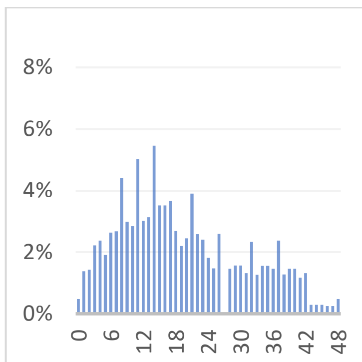

Figure 2E: Foundations-Untagged

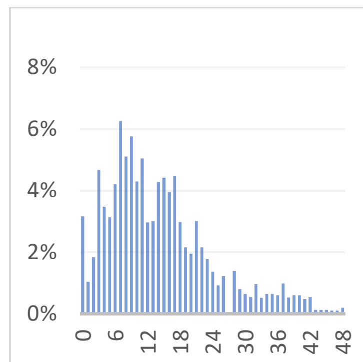

Figure 2F: Foundations-Combined

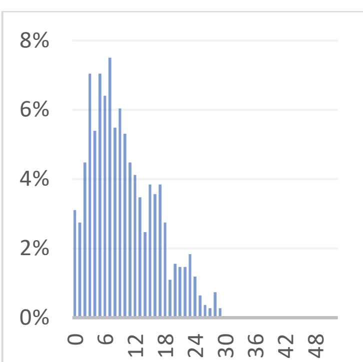

Figure 2G: All Types-Tagged

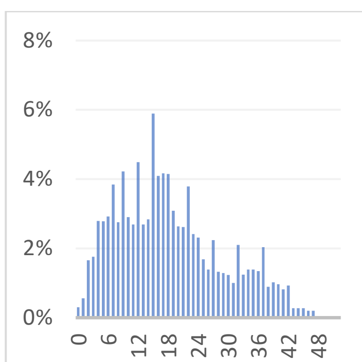

Figure 2H: All Types-Untagged

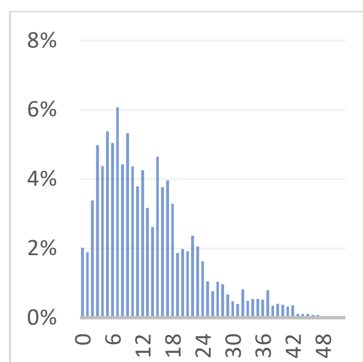

Figure 2I: All Types-Combined

Conclusion

This age study provides insights into the age distribution of mattresses and foundations in California. The large difference between the mean ages of tagged and untagged units suggests that older mattresses and foundations may be more likely to have their tags removed or become illegible. This information could be valuable for improving recycling processes and identifying areas where additional efforts may also improve age identification.

The data also indicates that a significant percentage of mattresses are discarded prior to the end of their useful lives. Further research is required to understand underlying factors which contribute to the decision by a consumer to discard a mattress, as well as recent changes in the relative market share of different mattress types.

By understanding the current state of the industry and the age of units being recycled, stakeholders can make informed decisions and develop effective strategies to improve recycling processes, reduce waste, and promote sustainability.