ÓBUDAI EGYETEM
Rejtő Sándor Könnyűipari és Környezetmérnöki Kar
Terméktervező Intézet

DEGREE PROJECT

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2021	Student's registration number:	**T-2838/FI12904/R**

ÓBUDAI EGYETEM
ÓBUDA UNIVERSITY

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THESIS ASSIGNMENT

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Thesis number: SZD21060915053264
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Branch of study: Industrial Design Engineering (Bsc)
Specialization: Packaging design

Thesis title: Pill Box Design for Patients with Cronic Disease or for People Taking Occasional Supplement
Task description:
1. Creating a user experience survey targeting pill organizer users, health care professionals and caregivers. Analyzation of existing products on the market. Thesis schedule.
2. Market research, analysis of the poll results. Material and form experiments. Setting list of requirements.
3. Sketches and development of at least 3 variations. Choosing the material based on requirements. Analysis and selection of final product design. Corporate identity and mobile application concepts.
4. Cost plan and technical drawings of the product. Creation of the visual presentation, renders and a poster (70x100cm). Creation of prototypes.

Institutional consultant's name: Dr. Róbert Németh

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The thesis is: Not secreted.

Issued: Budapest, 04.11.2021. P.H.

.....
Director of Institute

The Thesis is suitable for submission:

.....
Institutional consultant

.....
External consultant

Annex V/6

ÓBUDA UNIVERSITY

Rejtő Sándor Könnyűipari és Környezetmérnöki Kar

STUDENT'S DECLARATION

I the undersigned student hereby declare that this degree project / thesis is the result of my own work; I have disclosed the references and tools used in an identifiable manner. The results indicated in the degree project / thesis completed may be used by the university and the institution announcing the task to their own purposes free of charge, subject to any restrictions regarding confidentiality.

Dated: Budapest, 14th December, 2021

.....

student's signature

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1. GATHERING INFORMATION:

1.1. History

17th century - Pillboxes were present almost from the 17th century and served for more than storing pills, but they were considered artifacts also used to display art *(refer to figure 1.1.1 and 1.1.2).* They were made from any material available, from wood to different metals and even bones. In the beginning, they were designed to be placed on the nightstand or table. But then, the need for portability grew; hence the size reduced to fit in a purse. Usually, the boxes were embezzled with figurines or painted stories and were sold at auctions for high prices; however, the quality of the paintings and engravings on the pillboxes were declining as they had to become smaller, and so the figures became blurred and undetailed. As the boxes became smaller, they were regarded as jewelry, and Tiffany's had a line of pillboxes designed.[1] Although the boxes stored the pills, they didn't remind people when to take them, and therefore, the use of just the pillbox declined, and many inventions appeared to reach our modern-day SMTWTFS (Sunday, Monday, Tuesday…) plastic boxes.

Figure 1.1.1: pill box that has a classical scene painted on it. [1]

Figure 1.1.2: Vintage Italian Pill Box that features the Romantic Renaissance Courtship scene [2]

[1] *The history of pill boxes*. The Hunt Magazine. (2017, December 5). Retrieved December 12, 2021, from https://thehuntmagazine.com/life-style/pill-boxes/.

[2] https://www.etsy.com/listing/1021386229/vintage-italian-pill-box-oval-romantic?ga_order=most_relevant&ga_search_type=all&ga_view_type=gallery&ga_search_query=italian+pill+box&ref=sr_gallery-1-3

1929 - Since the 19th Century, many methods have existed to aid the patients and simplify caregivers' jobs regarding medication adherence, and more inventions were being released. One example is Mary C. Mottayaw's medication tray patented in 1929. [3] *(refer to figure 1.1.3).* The tray takes the shape of a clock allowing the patients or caregivers to lay down the pills at the exact time they are meant to be taken; therefore, they can see when to take their pill and recognize if they missed any. In addition, the tray has a spot in the middle in which the user can place a pocket watch, and therefore the hand of the clock will match the tray, and the patient or caregiver can see the time and take the pill corresponding to it. [4]

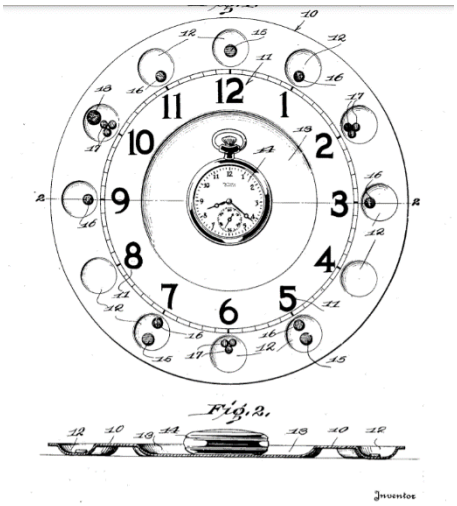


Figure 1.1.3: Mary C. Mottayaw's Tray design patented in June 11, 1929 [4]

[3] Gossel, P., 2021. Packaging the Pill. [online] Artefactsconsortium.org. Available at: <http://www.artefactsconsortium.org/Publications/PDFfiles/Vol1Med/1.05.Medicine-Gossel,PackagingThePillGrBlank3AWEBF.pdf>

[4] M. C. Mottayaw (1929). US Patent No. 1,717,060. Ohio: United States Patent Office.

1954 - During the 1950s, medication compliance was a priority, especially since the medical regimens became more complicated with antibiotics released into the market. Medical professionals measured a patient's compliance through blood and urine tests to monitor the concentrations of drugs in them, rather than finding solutions to ensure patient compliance through memory aid. In 1954 THE Trak-Pak dispenser was released to be sold as an addition to Squibb medication *(refer to figure 1.1.4).* The dispenser did not provide any memory aid to the patients; however, it was portable, and people felt they added value as they paid the same and got something extra. These remained and were again used with other medications and vitamins in 1962. [4]

Figure 1.1.4: Trak-Pak pill dispenser used by Squibb medication to promote aspirin [5]

[4] M. C. Mottayaw (1929). US Patent No. 1,717,060. Ohio: United States Patent Office.

[5] Google Books. 1955. LIFE. [online] Available at: <https://books.google.hu/books?id=QlQEAAAAMBAJ&pg=PA41&lpg=PA41&dq=Squibb+%22Trak-pak%22&source=bl&ots=IDGBQyx7ww&sig=ACfU3U12OaPiDOCXNCPOT9z8IYDmahUMuw&hl=en&sa=X&ved=2ahUKEwiv0dyjhojzAhUEs6QKHUNDAIgQ6AF6BAgQEAM#v=onepage&q=Squibb%20%22Trak-pak%22&f=false>

1962 - In 1962 David P. Wagner filed a patent for what became revolutionary in the pharmaceutical industry. The pill dispenser packaging idea came about due to Wagner's wife always forgetting to take her contraceptive pill as it had a complicated regimen; therefore, Wagner, a product engineer, decided to find a solution. [6] That is when he came up with pillbox packaging that has a memory aid *(refer to figures 1.1.5 (a) and (b)).* He created a pillbox model using acetate sheets and wood and filed for the patent in 1962. He then tried to approach some companies who produced contraceptive pills, but none of them agreed to use his packaging idea.[3]

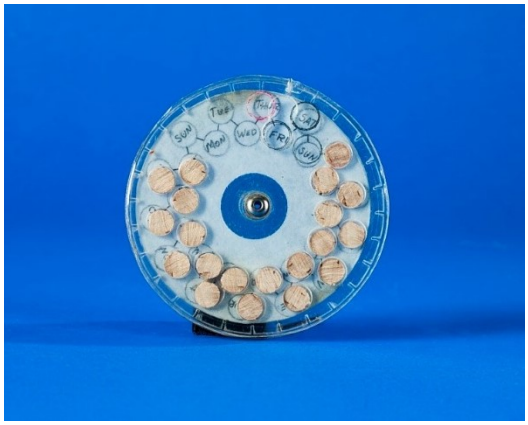


Figure 1.1.5 (a): Circular pill dispenser Prototype by David P. Wagner [6]

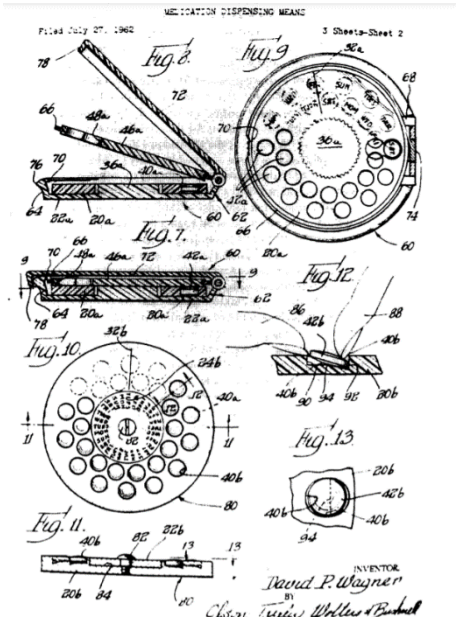


Figure 1.1.5 (b): David P. Wagner pill dispenser illustrations from the patent granted in 1964. [3]

[3] Gossel, P., 2021. Packaging the Pill. [online] Artefactsconsortium.org. Available at: <http://www.artefactsconsortium.org/Publications/PDFfiles/Vol1Med/1.05.Medicine-Gossel,PackagingThePillGrBlank3AWEBF.pdf>

[5] Wagner Pill Dispenser Patent Model. (n.d.). National Museum of American History. Retrieved October 10, 2021, from https://americanhistory.si.edu/collections/search/object/nmah_332970

1963 - One of the companies Wagner approached with his model is Ortho Pharmaceutical. In 1963, Ortho Pharmaceuticals released "DialPak," the first prescription drug to be compliance packaged *(refer to figure 1.1.6).* Each pill was packaged separately according to the day the user must take it, similar to Wagner's design. It was marketed as the package that "remembers for her." Ortho Pharmaceuticals proved that they could produce the pill package from cheap materials as a single-use package. Thereon after, that package could be recognized by anyone, it became famous, and many companies started using it, all of which paid Wagner royalties as it was his patented design. [3]

Figure 1.1.6: First Ortho DialPak dispenser [7]

It was common in the 1960s for women to hide their contraceptive pills so that people wouldn't know they were taking them, which created a trend for the aesthetic of pillboxes. It started with Wagner, who claimed that his design would fit into women's purses and seem compact like other female products. Following that, companies were designing compact pillboxes, pastel-colored with floral or cameo designs.[3] *(refer to figures 1.1.7 and 1.1.8).*

[3] Gossel, P., 2021. Packaging the Pill. [online] Artefactsconsortium.org. Available at: <http://www.artefactsconsortium.org/Publications/PDFfiles/Vol1Med/1.05.Medicine-Gossel,PackagingThePillGrBlank3AWEBF.pdf>\

[7] Wendt, Warner, D. W. M. W. (2015, June 19). Packaging the Pill. National Museum of American History. Retrieved October 11, 2021, from https://americanhistory.si.edu/blog/packaging-pill

The trend of disguising pillboxes remained even in the 1980s, where pillboxes were designed to look like wallets or credit cards. [3]

Figure1.1.7: Enovid-E compact pastel pill box with floral design [8]

Figure 1.1.8: Pill box disguised as compact makeup/mirror and advertised as discreet and elegant, by Ortho.[8]

[3] Gossel, P., 2021. Packaging the Pill. [online] Artefactsconsortium.org. Available at: <http://www.artefactsconsortium.org/Publications/PDFfiles/Vol1Med/1.05.Medicine-Gossel,PackagingThePillGrBlank3AWEBF.pdf>\

[8] CHAN, LUK, ROSMAN, YONG, I. C. A. L. M. R. S. G. (n.d.). Design: Packaging. Tenthingsthepill, Weebly. https://tenthingsthepill.weebly.com/design-packaging.html

1990s - Companies were trying to find new ways to help women remember their pills, to set themselves apart from the competition. Different designs for pillboxes with memory aid were designed and patented, for example, the pillbox with built-in alarm *(refer to figure 1.1.9).* Other companies tried to associate pill-taking with other daily routines such as brushing teeth or washing hands to remind patients to take their pills. For example, organon's "Remember me Compliance Kit" includes a toothbrush, a soap bar, a "Remember me" sticker for the bathroom in addition to the packaged pills. [3] *(refer to figure 1.1.10).*

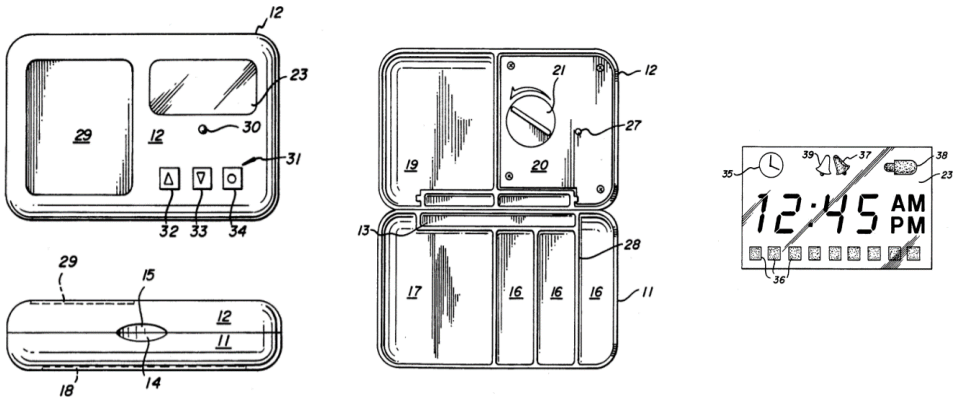


Figure 1.1.9: Alarm Pill box by Malcolm R Raven patented in 1991.[9]

Figure 1.1.10: "Remember me" compliance kit released in 1993 [10]

[9] Malcolm R. Raven (1991). U.S Patent No. 5,020,037.

[10]*Desogen Remember Me Oral Contraceptive Compliance Kit*. (n.d.). National Museum of American History. Retrieved October 11, 2021, from https://americanhistory.si.edu/collections/search/object/nmah_1273034

Present - Looking at the history of the pill box, it can be seen that since the beginning, the main goal is finding efficient ways to remind patients of taking their medication consistently. Over the years many ideas came about to solve that issue, and the one used most nowadays is the SMTWTF pill box which has compartments for all the days of the weeks. Some trends from the past remain important in today's pill box for example Portability. It is an important factor in previous and today's pill boxes as it ensures people will take their medication even when they are on the go. Another trend which remains in the present time is people preferring aesthetical boxes in order to hide the fact that they are pill boxes. Some examples in include casings with design elements where the pill box can be placed *(refer to figure 1.1.11).*

Figure 1.1.11: Floral cases to cover the plastic pill box. [11]

[11] *pretty pill box*. (n.d.). [Photograph]. Latimes. https://ca-times.brightspotcdn.com/dims4/default/52704c6/2147483647/strip/true/crop/2048x1367+0+0/resize/840x561!/format/webp/quality/90/?url=https%3A%2F%2Fcalifornia-times-brightspot.s3.amazonaws.com%2Fd3%2F73%2F87fb955c9b46d8d58da910691862%2Fla-trb-gear-a-pretty-pill-case-makes-having-to-001

Today's pill boxes can also be smart. As people's dependency on technology increases smart pill box designs are emerging with higher prices and efficient reminders, however there are not bought as often as normal pill boxes. In addition to that, modern looking boxes are becoming a trend with sleek simple design *(refer to figure 1.1.12).*

Figure 1.1.12: Nordic style pill box design [12]

1.2. Pill Boxes and Medication adherence

People who take multiple medications several times or every day of the week are more susceptible to issues with medication adherence. The main issue is forgetting. Firstly, forgetting which medication should be taken, secondly forgetting at what time each medication should be taken especially if they have complex regimens, and sometimes forgetting to take the medication as there are many boxes each in different place and not close to the patient. All these problems can be reduced by using a pill box as the pills are organized in separate compartments according to the days they are supposed to be taken, thus reducing or completely eliminating the mess of having many boxes and trying to figure out which one should be taken. That's why even health professionals recommend patients to use pill organizers especially for the elderly as with age the number of medications the person has to follow increases.[13]

Older or younger people who have chronic diseases or take vitamins and supplements daily would need to keep their pills with them so it doesn't hinder their daily activities. A pill box allows that for them and reduces the stress of planning their day according to their medication schedule. This is important especially for older people to keep them active in the community and independent while following their medication regimen.[14]

Patients are also advised to keep a list of the medication doses and prescription information and side effects in a list to keep track of the important information and not be of a health risk.[15] On the other hand, health concerns arise from using pill boxes because most medication's effectiveness depends on the timing they are taken and therefore people relying on their memory to take the pills offers a health risk. Moreover, having more than one pill in one compartment poses a serious health risk of taking the wrong pill at the wrong time, as it is not enough to remember the shape of the pill and the color especially that those might change or some pills can look similar but they are extremely different *(examples in figures 1.2.1 and 1.2.2)*

[13] A. (2021, January 27). The Benefits of Using a Pill Box Dispenser. Shantys - Pillmate Pill Box, Nit Comb and Pill Accessories. Retrieved October 11, 2021, from https://www.shantys.com/2017/11/benefits-using-pill-box-dispenser/

[14] de BorjaOliveira, C. R. (2013). Analysis of the audit factor structure in . . . - scielo.br. Scielo. Retrieved October 10, 2021, from https://www.scielo.br/j/rsp/a/wWq6LsHNFnRSD4Snj6WgqSC/?format=pdf&lang=en

[15] Vorvick, L. J. V. (2020). Keeping your medicines organized. Medline Plus. Retrieved October 12, 2021, from https://medlineplus.gov/ency/patientinstructions/000600.htm

Figure 1.2.1 (a): Panadol (paracetamol); pain killer pill [16]]

Figure 1.2.1 (b): Calcium and vitamin D pill [17]

Figure 1.2.2 (a): vitamin c pills [18]

Figure 1.2.2 (b): Plavix(clopidogrel) medication to prevent heart strokes, blood thinner help with arterial circulation.[19]

Moreover, some pills are packaged in special vials to prevent moisture and light from entering which cannot be ensured when using a pill box. In addition to the mentioned issues, one of the biggest concerns is distributing pills into the pill box. The process of removing pills from their original package and filling them in the right days and times of the pill box, can incur many errors. Therefor it is always advised for a person to recheck the sorting to reduce possible errors.[20]

There are many types of pill boxes; some with bigger compartments, some with 7 compartments for the days of the week, some with built in alarms to remind the patient to take their pill... etc. They could be sold anywhere and are not subject to legal requirements or specific instructions of use. Original packaging of pills ensures the right conditions for the medicine locking out the moisture, light and having a specific temperature, therefore removing it from its original can impose risks on the patient.[21]

[16] https://shopee.com.my/Panadol-Advance-Panadol-Optizorb-Caplet-500g-i.19172982.2634767159

[17] Calcium. (n.d.). [Photo]. Nutrstock. https://149361871.v2.pressablecdn.com/wp-content/uploads/2018/03/5230.jpg

[18] Jeffcott, N. J. & Stocksy. (n.d.). Vitamin C tablet [Photo]. Everyday Health. https://images.everydayhealth.com/images/possible-benefits-of-vitamin-c-supplements-1440x810.jpg?w=1110

[19]https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.goodrx.com%2Fclopidogrel%2Fwhat-is&psig=AOvVaw3St1TA8cnNETTe25KWiI-N&ust=1632481331194000&source=images&cd=vfe&ved=0CAwQjhxqFwoTCNCQy5r5lPMCFQAAAAAdAAAAABAX

[20] Basaraba, S. B. (2020, March 21). Are Pillboxes for Multiple Medications Safe? Verywell Health. Retrieved October 11, 2021, from https://www.verywellhealth.com/pillboxes-and-drug-safety-2224150

[21] Borja-Oliveira, C. R. D. (2013, February 1). Organizadores e cortadores de comprimidos: riscos e restrições ao uso. Scielo. Retrieved October 12, 2021, from https://www.scielo.br/j/rsp/a/wWq6LsHNFnRSD4Snj6WgqSC/?lang=en

1.3. Analyzing Existing Products

1.3.1. 7-day Organizer

Figure 1.3.1.1: 7-day plastic pill organizer [22]

The most basic and the common is the 7-day pill organizer which consists of 7 compartments each labeled according to the day of the week where all Mondays pills will be placed in the Monday compartment and so on.

Pros:

- Organizes the pills a person has to take into their specific days.
- Can show if you took pill or not if there are 3 or less pills in the day
- Light weight and portable.

Cons:

- If the person has to take more than 3 pills a day it can become confusing and mixing of pills might occur, as all pills are in the same compartment.
- No indication which pill should be taken and which time.
- Dependent on persons memory, no reminders to take pills.
- Has to be refilled every week.
- If many pills are placed in one compartment it would be difficult to remember whether the medication was taken or not

[22] APEX 7- DAY PUSH TO OPEN PILL ORGANIZER. (n.d.). [Photo]. Carex. https://cdn.shopify.com/s/files/1/0240/6504/8681/products/carex-com-pill-organizer-apex-7-day-push-to-open-pill-organizer-28287852937321_1000x.png?v=1621616874

1.3.2. Weekly pill organizer 4 times a day (morning, noon, evening, night)

Figure 1.3.2.1: Multi colored grid weekly organizer [23]

A weekly organizer with 3 or 4 compartments for each day of the week indicating the approximate time the medication should be taken morning, evening or night.

Pros:

- Unlike the basic 7 days pill box, there is some indication when to take certain pills.
- If a person takes more than 3 pills they are separated in different compartments and not in one compartment which reduces the likeliness of mixing between pills
- Usually, its modular which means the compartments for 1 day can be separated from the rest so it can be easier to carry.

Cons:

- No reminder to take medication, therefore depending on a person's memory.
- Usually, the compartments are smaller and cannot fit multiple pills or bigger vitamins.

[23]Weekly Pill Organizer. (n.d.). [Photo]. Amazon. https://www.amazon.com/Organizer-Compartments-Moisture-Proof-Medication-Supplements/dp/B07Q9JSHMP

1.3.3. Electronic Pill box

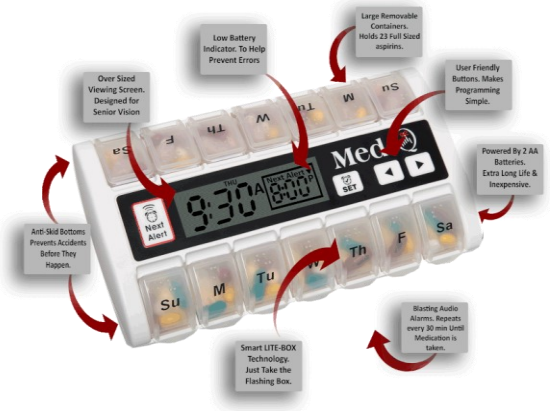


Figure 1.3.3.1: Electronic Pill organizer with built in alram and light indicator [24]

Electronic pill boxes are a version of the basic 7-day pill box or the weekly 4 times a day pill box but with the addition of light or sound reminders.

Pros:

- They have a reminder mechanism whether an alarm or lights or a combination of both ensuring that a person takes the pill at the right time.
- Organizes the pills a person has to take into their specific days.
- Can show if you took pill or not if there are 3 or less pills in the day

Cons:

- If it was a 7-day pill box with 7 compartments the same disadvantages apply as before. (confusing pills, not knowing which pill to take,)
- Although the size of an electronic pill box can be suitable for carrying however because they have built in alarms, they are not ideal to be taken everywhere due to the noise.
- Pill box will need batteries or to be recharged and if not, it will be a normal pill box without reminders having the same disadvantages as in 1.3.2 and 1.3.2.

[24] electronic pill box. (n.d.). [Gif]. Med Q. https://i1.wp.com/medqpillbox.com/wp-content/uploads/2019/09/gallery-pic-6.jpeg?fit=1150%2C800&ssl=1

1.3.4. Smart pill box

Figure 1.3.4.1: Ellie Grid Smart pill box [25]

Smart pill boxes are usually pill boxes that sync to an app and also include light or sound reminders to take pills.

Pros:

- Has reminders – both built in and app reminders
- Has sensors for when a compartment is opened and a pill is taken
- Sleek modern design
- Easy refill

Cons:

- Expensive
- Pill box should be charged and if not, it loses its smart abilities
- Complex to use for the elderly, hard to open especially if user has arthritis.
- Reminders are too brief and if not taken quickly the light and reminders turn off.
- Beeping sound and lights makes it hard to be portable especially to work or school.

[25] Ellie Grid. (n.d.). Elliegrid Smart Pill Box [Photo]. Ellie Grid. https://cdn.shopify.com/s/files/1/3102/2852/products/JPEGimage2_1_900x.jpg?v=1625605884

Disadvantages of smart pill boxes were deduced from user reviews of the product which can be seen in the screenshots below. (Refer to figure 1.3.4.1)

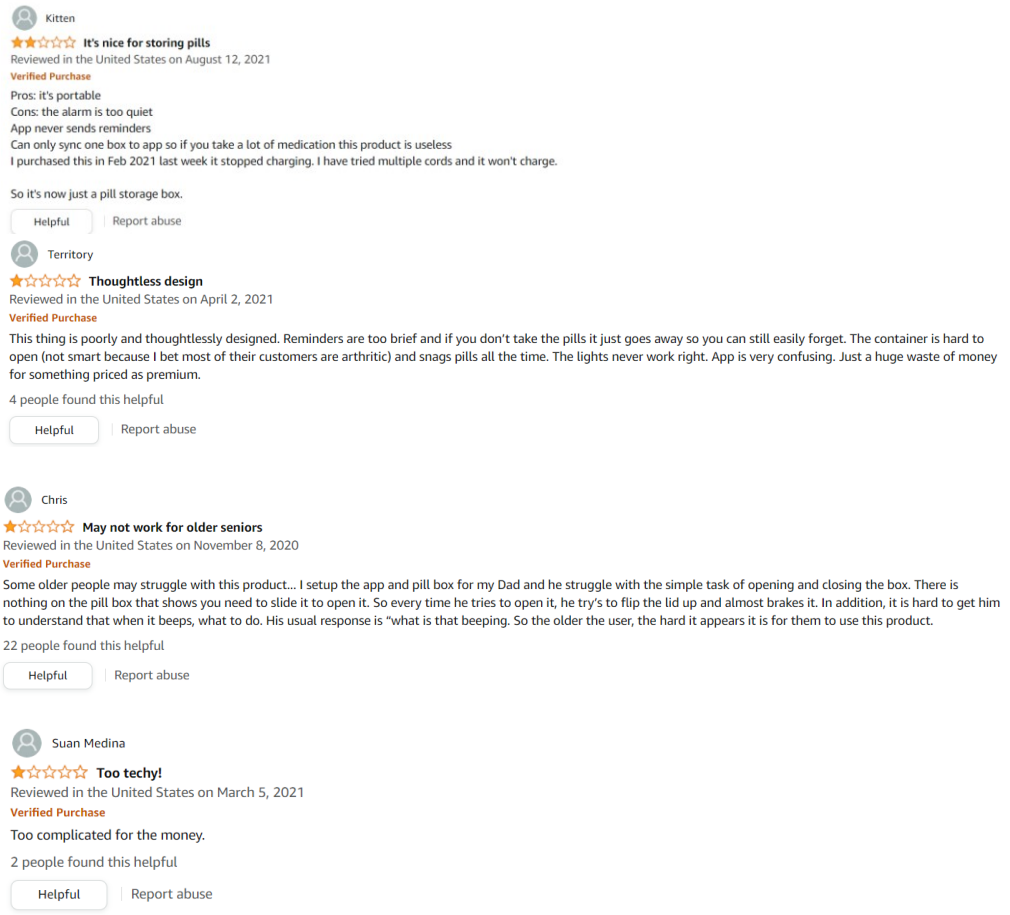


Figure1.3.4.2: Screenshot of amazon reviews to assess product usability

1.3.5. Home medical system:

Figure 1.3.5.1: Easy Pill medical System directed towards the elderly [26]

Pros:

- Has auditory and visual reminders which are important especially for the elderly
- Syncs to an app creating a health record for caregivers to monitor.
- Each different medication is in a compartment of its own eliminating risk of taking the wrong pill
- Modern sleek design

Cons:

- Not portable-does not suit occasional users or give the elderly independence
- Expensive

[26] Chang, Bhattacharya, Tahsin Emre Eke, Yuhang Yang, C. C. S. B. T. E. Y. Y. (n.d.). *Easy Pill medical system* [Photo]. Tuvie. https://www.tuvie.com/wp-content/uploads/easy-pill-medical-system2.jpg

1.4. Presentation of Precedents

Being surrounded by older family members, with chronic illnesses or members who abide by a strict vitamins and supplements regime a common issue was noticed; taking pills is a complicated task that hinders daily activities even with the use of a pill box.

Therefore, it was clear that a pill box redesign was needed.

Referring to the positives of the existing most used pill box *(SMTWTFS, refer to section 1.3.1)* it was apparent that some features still work and can remain in the new design, these include:

1. Separate compartment for each day
2. Portability

However, the other parts could be improved to simplify taking medications.

Firstly, the closure. According to scientists, pills can be affected negatively by light, moisture, heat and air therefore storage information are important to be read and also removing the pill from its original package can damage it as the primary package ensures the safety of the pills.[27] Therefore, as an inspiration for the pill box design, research was conducted to understand the closing mechanism of airtight food containers/pantry storage.

Figure 1.4.1: Pantry storage sir tight containers with silicon edge.[28][29]

[27] Vorvick, L. J. V. (2020b, January 23). Storing your medicines. Medline Plus. Retrieved October 15, 2021, from https://medlineplus.gov/ency/patientinstructions/000534.htm

[28] OXO POP 2.7qt Airtight Food Storage Container. (n.d.). [Photo]. Target. https://www.target.com/p/oxo-pop-2-7qt-airtight-food-storage-container/-/A-15672341#

[29] *TASTY+ square storage jar 1.6 L*. (n.d.). [Photo]. Nordic Nest. https://www.nordicnest.com/assets/blobs/brabantia-tasty-square-storage-jar-16-l-dark-grey-storage-jars/505728-01_1_ProductImageMain-f90363ec99.jpg?preset=medium

Second part is portability. Although the existing plastic pill boxes are portable yet portability can still be improved. Having a flat object to pack is easier than a bulkier, or thicker item as it takes less space and fits in today's laptop bags, handbags, …etc.

Figure 1.4.2: Non flat object in bag VS. Flat object. (author's own image)

The third part is, ease of taking pills and ensuring that the user handles the pills only when necessary. Existing pill cases have smaller yet deeper compartments which might fit 10 pills but usually they are arranged on top of each other which means a person who takes many pills has to remove all the pills from the compartment in order to reach the desired pill. This could be solved with a flat box so that the pills are arranged side by side so that the user can access any pill without handling the other pills. While having rounded edges from the inside of the compartments can facilitate the ease of taking out the pills as they could slide the edge and taken out of the compartment.

1.5. Market Research

Primary and secondary market research is needed in order to identify the gaps in the market and understand first hand users experience.

1.5.1. User Experience Survey

As part of market research, an online survey was conducted targeting pill box users, health care professionals and caregivers whether professional, volunteers or caring for family member, to identify the issues with existing products and ensure that there is a market for the product which will be designed.

Questions of the survey:

(Note that the person who needs care is referred to as client)

1. What is your age?
    a. Under 18
    b. 18-24
    c. 25-34
    d. 35-44
    e. 45-54
    f. 55-64
    g. 65+

2. Which of the following best describes you?
    a. I own and use a pill organizer
    b. I am a caregiver and I am responsible of keeping track of my client's medication schedule (either professionally or of a family member)
    c. I am a health care professional/ I have experience in using pill boxes
    d. Other

3. Which of the following best describes you?
    a. Occasional Pill box user (I use it to organize my vitamins and supplements)
    b. Regular pill box user (I have chronic health conditions and use the box daily)
    c. Other

4. How many different medications (of which are pills) do you / your client(s) take?
    a. Less than 3
    b. 3
    c. 4-5
    d. 6-7
    e. Other (10+)

5. How many pills do you/your client(s) take in a day? (average)
    a. 1-2
    b. 3-5
    c. 6+
    d. Other
    e.

6. What type of pill box do you / your client(s) use?

(Refer to section 1.3 for figures)

    a. 7 days plastic pill box *(refer to figure 1.3.1)*
    b. Weekly pill organizer with 3-4 compartments for each day (morning, noon, (evening), night). *(Refer to figure 1.3.2)*
    c. Electronic pill box. *(Refer to figure 1.3.3)*
    d. Smart pill box. *(Refer to figure 1.3.4)*
    e. Pill organizing home system. *(Refer to figure 1.3.5)*
    f. Other

7. Do you carry your pill box with you when you go out?
    a. Yes- always
    b. Yes-sometimes
    c. No
    d. Does not apply to me, I am a caregiver.

8. If your answer was "No" to the previous question please answer why.
    a. My medication Schedule does not overlap working hours or going out.
    b. I am in a care home
    c. I have multiple pillboxes that I keep at places I’m frequently at
    d. Other

9. What are some problems with the pill box/ organizer?

(Multiple answers could be checked)

a. Forgetting to take pills (no reminder)
b. Forgetting if I took pill or not
c. Taking pills at inconsistent times
d. Confusing pills/ mixing up pills
e. Compartments are too small to fit my vitamins/supplements or all my meds
f. My pill organizer is not portable (too bulky, heavy, or insufficient closure)
g. Time wasted refilling pills
h. High cost for smart pill box
i. Losing the prescription information due to separation from original package
j. Bad quality box (wears easily)
k. Box is not modern/aesthetical
l. No problems with my box, its perfect
m. Other

10. How do you remember to take your pill on time? (if applicable)

a. I remember by myself due to routine
b. Someone (caregiver) reminds me to take my pills
c. I have reminders on my smartphone, tablet, smart watch…
d. I have an alarm clock / reminder gadget

11. How do you ensure that the client takes their medication on the right time? (if you are a caregiver)
    a. By following a printed schedule and filling the information manually
    b. Through reminding devices
    c. Through a system that stores client's information and medication schedule.
    d. Other

12. Have you or the person you take care of ever had a medical issue/complication, or treatment-resistance due to bad medication adherence (forgetting to take pill, taking the wrong pill, taking medication at inconsistent times)?
    a. Yes
    b. No

The purpose of the survey was to evaluate the existing problems with pill boxes among different age groups and to identify potential design improvements tailored for the audience which are occasional and regular pill box users. The results for 75 people were collected and analyzed in order to come up with a functional efficient design.

1.6. Statistics

People are becoming more aware about their health and therefore the market for vitamins and supplements is growing and self-medication from over-the-counter pills is increasing in Europe *(refer to figure 1.6.1).* This provides an opportunity for a pill box design that not only serves people with severe illnesses but also occasional pill takers who want to organize their supplements and vitamins.

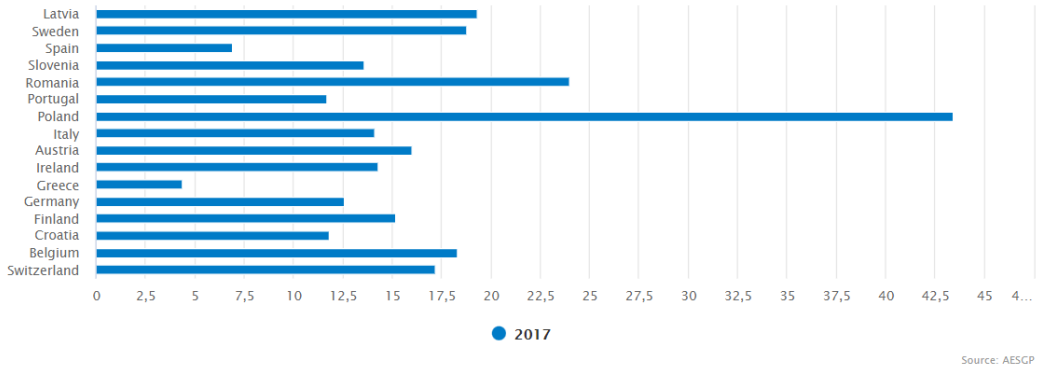


Figure 1.6.1: Non-prescription share of pharmaceutical market in European countries [30]

A study by M. Christopher Roebuck a director of health economics and strategic research, Joshua N. Liberman vice president of strategic research, Marin Gemmill-Toyama a health insurance specialist, and Troyen A. Brennan a chief medical officer find evidence that improved medication adherence leads to lower health care use and lower costs related to health care. The research shows that even though the pharmacy costs are increasing however the costs of hospitalization and emergency attendance is decreasing due to people taking their medication correctly.[31] This proves the importance of medication adherence in reducing adverse health issues.

[30] Ecovia Intelligence. (2020, December 30). *Which trends offer opportunities or pose threats on the European natural ingredients for health products market? | CBI*. CBI Ministry of Foreign Affairs. Retrieved October 15, 2021, from https://www.cbi.eu/market-information/natural-ingredients-health-products/trends#increase-in-over-the-counter-medicines-and-self-care-products-in-europe

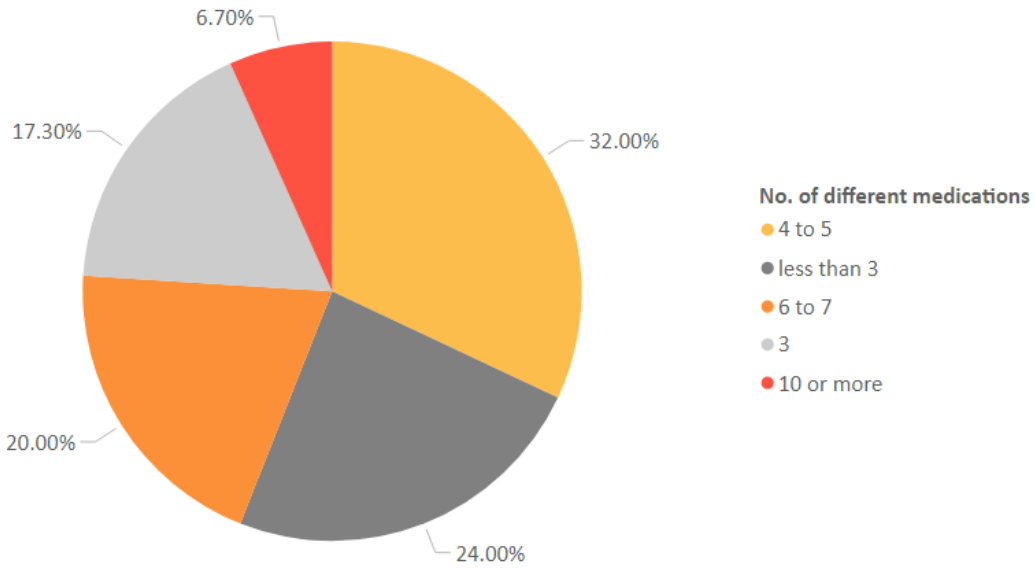
[31] Roebuck, Liberman, Toyama, Brennan, M. C. R. J. N. L. M. T. T. A. B. (2011). *Medication Adherence Leads To Lower Health Care Use And Costs Despite Increased Drug Spending*. Health Affairs. Retrieved November 10, 2021, from https://www.healthaffairs.org/doi/pdf/10.1377/hlthaff.2009.1087

2. ANALYSIS

2.1. Results of the User experience Survey

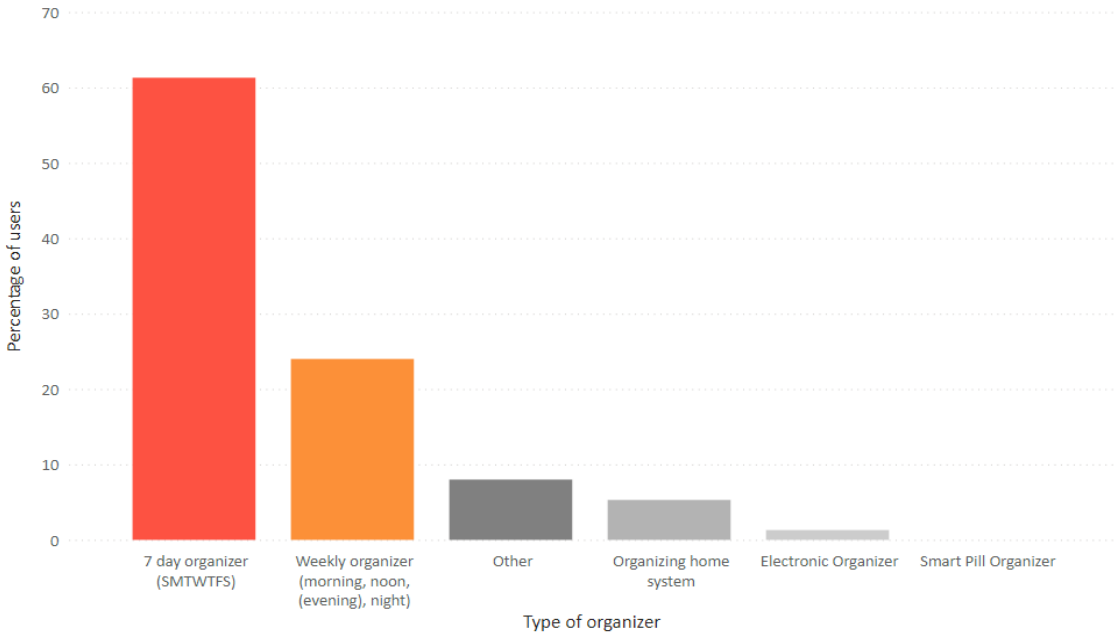
Looking at the results of the questionnaire, many conclusions can be drawn.

Firstly, almost 59% of the primary audience takes 4 or more different types of medication, with 6.70% taking 10 or more different pills, which shows that more than half are susceptible to confusing or forgetting pills. Moreover, it shows the need to have a pill box with big enough compartments to fit the pills and reduce the confusion between pills. *(Refer to visualization 2.1.1)*



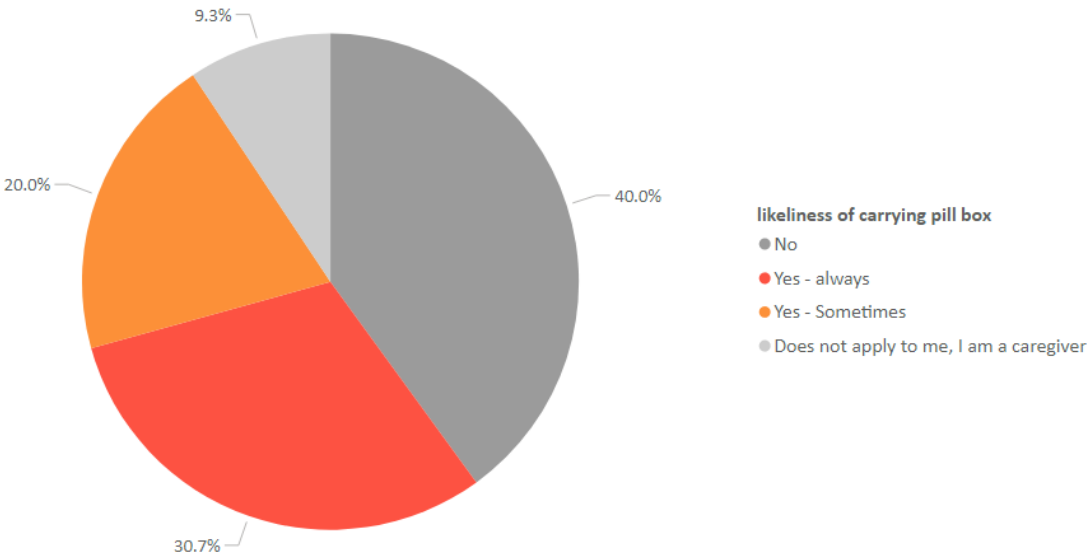
Visualization 2.1.1: Pie chart showing that more than half of the target audience takes 4 or more pills and hence are more susceptible to medication errors. (Made by Author)

According to the questionnaire the most used pill box is the 7-day organizer with 60% users and following that with 24% using the weekly organizer with morning, evening, and night compartments, and 0% using smart pill boxes. This shows that people prefer simpler more cheaper methods rather than complex high maintenance pill boxes even though they include better reminders. *(Refer to visualization 2.1.2).*



Visualization 2.1.2: This chart shows that the most used pill organizer is the simple 7day organizer followed by the weekly organizer with 3-4 compartments a day. (Made by Author)

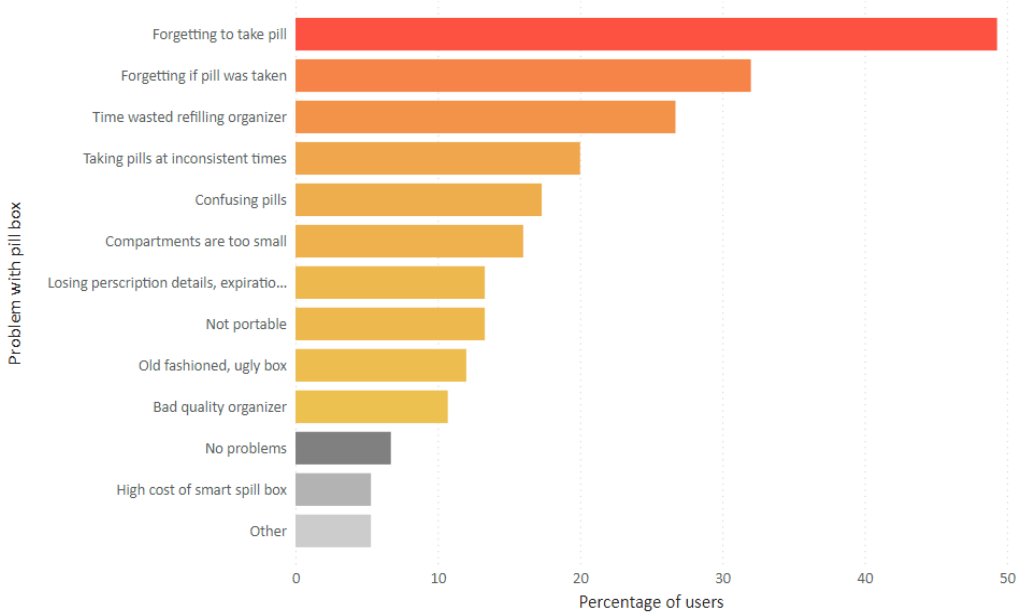
As for the importance of portability, almost 47% of the users said they carried their pill box with them either regularly or occasionally which proves that the designed pill box should have the features to be portable to suit the lifestyle of a working person or an elderly who is not in a care home. *(Refer to visualization 2.1.3)*



Visualization 2.1.3: This pie chart shows the response of users when asked if they carry their pill box with them when they leave the house (Made by Author)

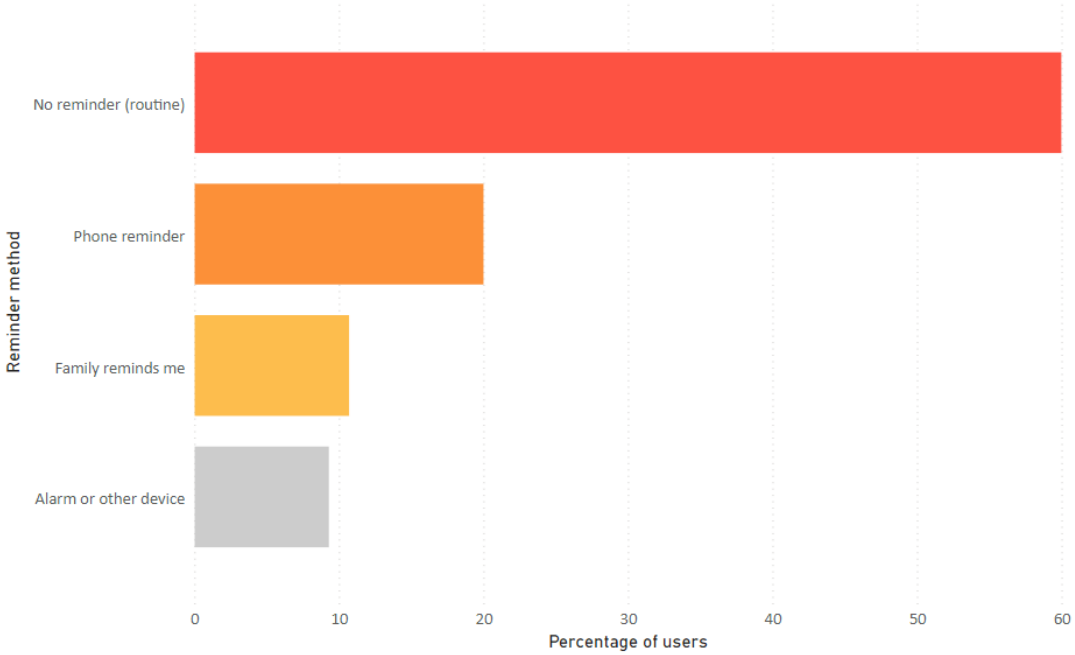
The number one problem with pill boxes according to the users is forgetting to take pills, followed by forgetting whether they took the pill or not. This presents an opportunity for a new pill box redesign that solves these issues by providing a memory aid. Other problems include taking pills at inconsistent times and confusing pills, which are also memory problems of when to take pills and how the pills look like as they are not in their original package.

In addition to memory related problems, other issues related to the container itself were agreed upon such as, small compartments, ugly design, bad quality and other issues that create an opportunity for a new design. *(Refer to figure 2.1.4)*



Visualization 2.1.4: This chart shows the problems with existing pill boxes according to the users, with the top issues being related to memory. (Made by author)

Another important conclusion after looking at the questionnaire is that most people depended on their memory rather than reminders of any sort to take their pills which is not reliable and can pose serious medical issues especially in the case of caregivers as they are responsible for someone's life therefore relying on memory is not a preferred method. The second most used method is phone reminders with 20% and after that is depending on a family member 11%. All of this information provides a market for a pill box with an easy phone app reminder to ensure adherence and safety while being the least complex and also keeping the family informed if needed. *(Refer to visualization 2.1.5)*



Visualization 2.1.5: This chart shows that the majority of the users depend on their own memory to take their medication. (made by author)

Lastly, 33% of the total people said that they/the person they take care of have faced medical complications or treatment resistance due to bad medication adherence, although that is less than half, it is still a big percentage and shows the importance of a better pill box design that ensures adherence, and consistency. *(Refer to visualization 2.1.6)*

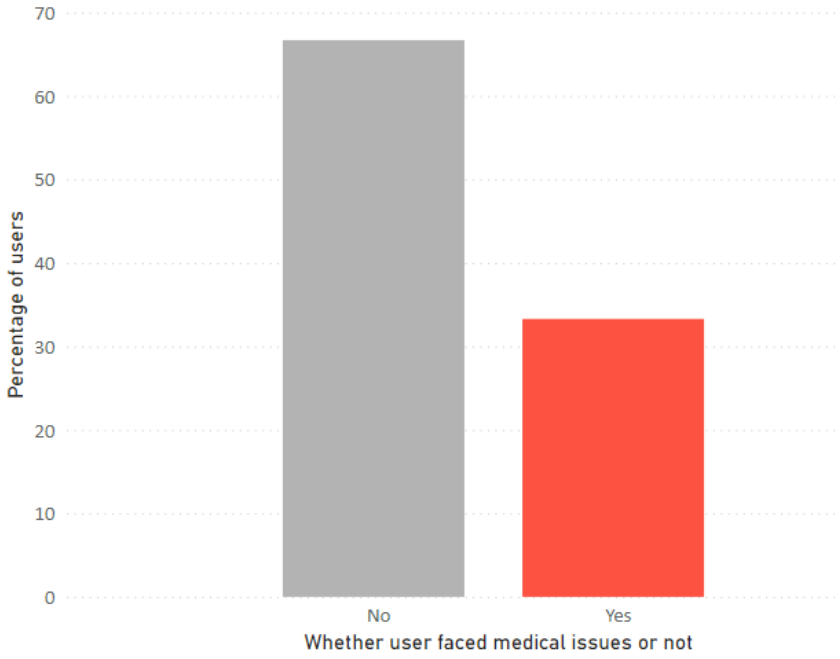


Figure 2.1.6: Shows the percentage of users that faced a complication or medication resistance due to bad medication adherence. (Made by Author)

2.2. Target Group

The main target group of the pill box are occasional pill takers who take some pills and or supplements and vitamins, and regular pill takers who have chronic illnesses and need to rely on a pill box every day to ensure a proper medication schedule. Care givers are also a huge part of the target group as they can rely on a pill box and reminder system to care for their client and therefore considered a customer and huge influence on the user.

2.2.1. Persona 1

Laura Bederna

Age: 40

Profession: HR Manager

Location: Budapest

Laura is a 40-year-old who works out and maintains a healthy lifestyle. Taking vitamins and supplements accompanies that lifestyle. However, as a working mom she has a busy lifestyle, especially that she also cares for her elderly father. Therefore, sometimes she ends up forgetting to take her vitamins, and to call to check her father took his medication.

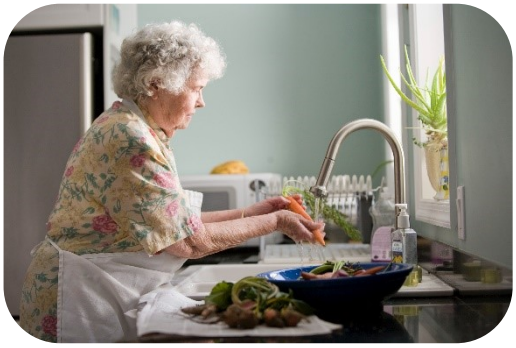
Wants and Needs:

- Solution to remember pills
- An easy way to track her father's medication
- A safe place to organize her pills
- A professional pill organizer that she can take with her to work and put on her desk without attracting unnecessary attention.

Frustrations:

- Forgetting to take her pills
- Forgetting to check if her father took pills
- Forgetting if she took pill
- Existing pill boxes do not suit her home and office aesthetic, they look cheap.

2.2.2. Persona 2



Anna Varga

Age: 70

Hobbies: Playing Cards with friends

Location: Budapest

Anna is an outgoing 70-year-old woman who lives alone and can take care of herself. She has some chronic diseases and takes 12 different medications including her vitamins. Her son and daughter take care of her when needed and ensure she adheres to her medication. Although she owns a pill box the compartments are too small for all her medication and too packed so sometimes, she is not sure which of the medication she has to take as some look similar.

Wants and Needs:

- Pill box that can fit all her medication
- Reminder to take pills, and a proof she already took pill or not.
- Keeping her family updated on her meds.
- Easy way to carry her medication when she sleeps at her sons or daughters house or when she goes to play cards.

Frustrations:

- Forgetting to take her pills
- Not knowing which pill to take, as there are too many
- Forgetting if she took pill
- Compartments in her pill box are too small, so she needs multiple which are difficult to carry.

2.3. Requirements

The designed pill box should simplify a complicated medication regime in order to ensure the effectiveness of the prescribed medication and reduce the risk of any complications due to missing pills or taking wrong pills.

Therefore, the pill box should:

1. Have an effective closure to ensuring the right environment of pills. Blocking out moisture, light and air.
2. Have big enough compartments to fit vitamins and supplements or as many pills as the user takes.
3. Simplify taking pills out of the compartments, with least handling of pills.
4. Have a sleek modern design to fit into the everyday user's lifestyle.
5. Reduce persons contact with pills/handling of pills (touching the pills with hands) in order to avoid moisture and bacteria affecting the pills. Especially with pills that can dissolve easily.

And the Application should:

1. Remind the user to take their pills at consistent times every day.
2. Remind the user that they already took their pill.
3. Remind the user to take the pill box when needed.
4. Remind the user to refill pill box.
5. Show the user a picture of the pill to avoid pill confusion.
6. Provide important basic information such as side effects, expiration date…etc. as pills are removed from their primary package.

3. CONCEPT GENERATION

3.1. Plan Variations

3.1.1. Design Plan 1

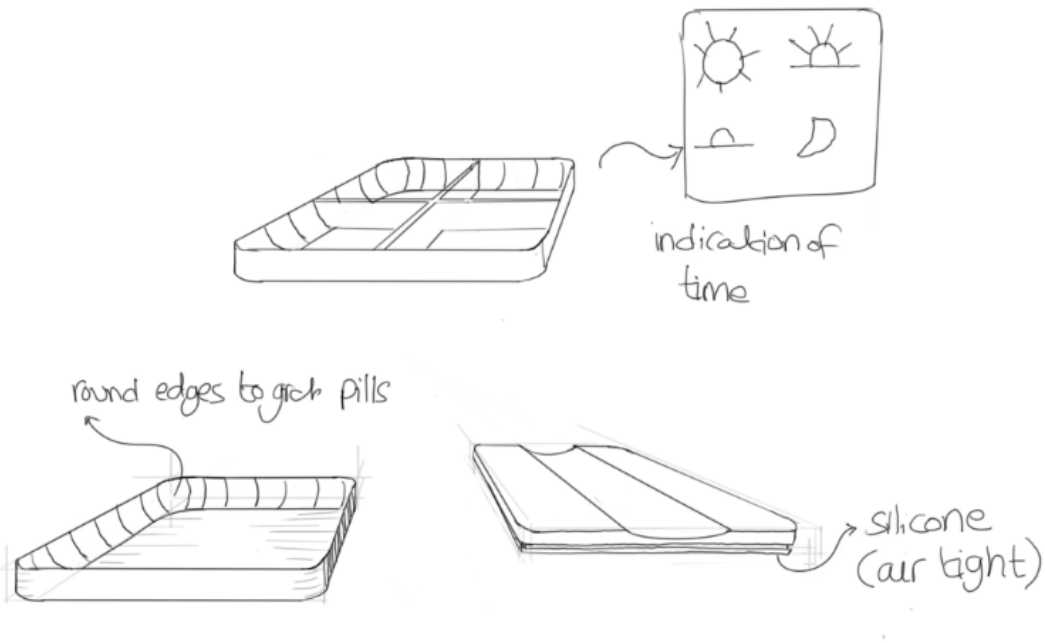


Figure 3.1.1.1: Design sketch 1: Flat pill box (Made by author)

3.1.2. Design Plan 2

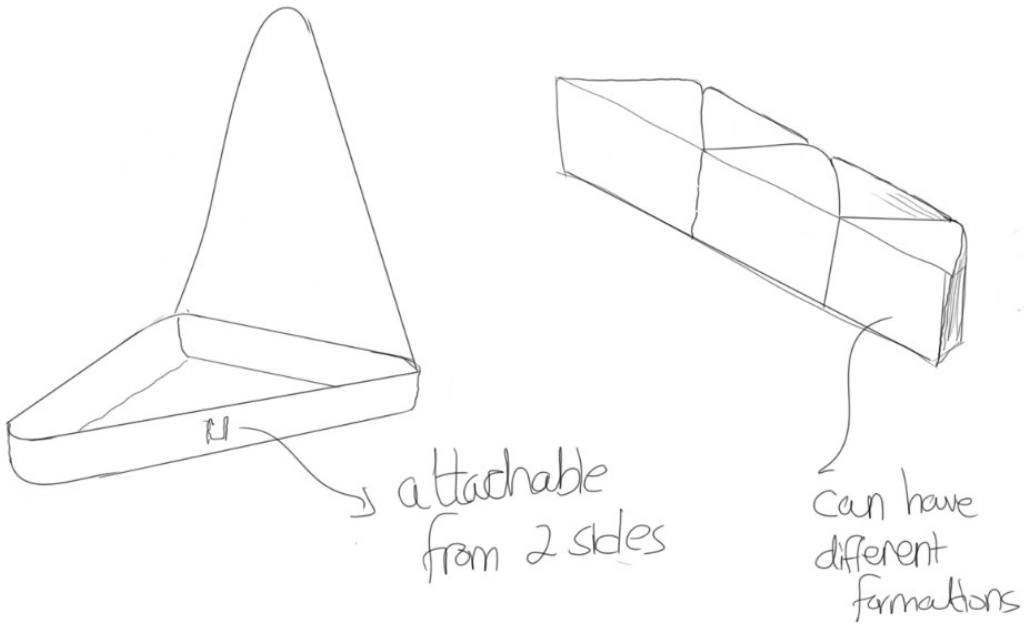


Figure 3.1.2.1: Design Sketch 2: Modular design (Made by Author)

3.1.3. Design Plan 3

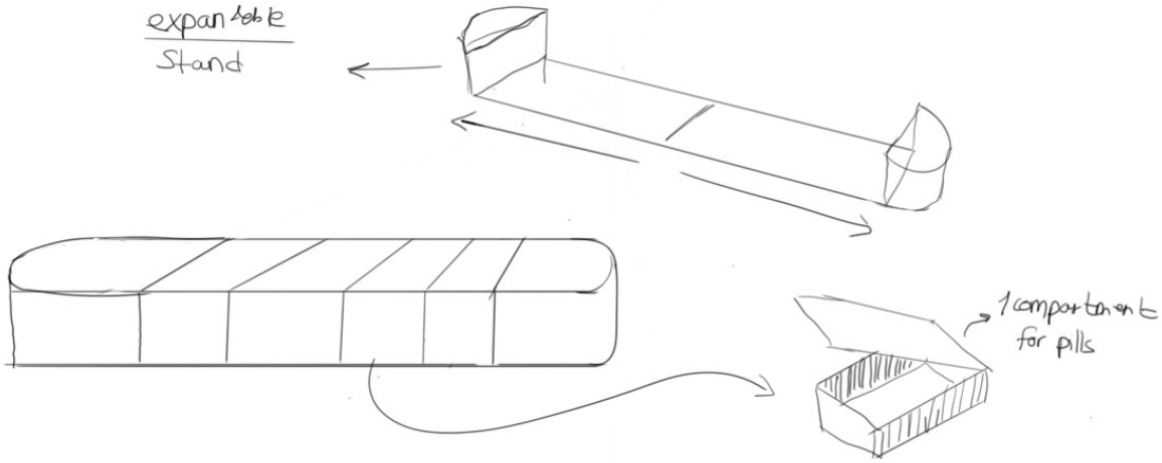


Figure 3.1.3.1: Design Sketch 3: Expandable Stand (Made by Author)

3.2. Analysis of Design Ideas

3.2.1. Design Idea 1: Flat Box

The design tackles the problems of portability, confusing pills, handling pills, and complicated pill regimes.

Features:

1. Flat shape

This feature allows the design to be easily portable and placed in any bag pocket without being bulky and taking up space. Most of todays bags include spots for laptops, tablets, phones all of which are flat design and therefore the pill box fit into that lifestyle. Moreover, the flat design ensures that the pills stay aligned side by side instead of on top of each other unlike the existing 7-day and weekly pill boxes, which means the user can see all the pills and access the pill they have to take without removing all the pills from the compartment. *(Refer to requirements in section 2.3.)*

2. Rounded Inner Edges:

This feature allows the user to take out pills easier by sliding them up the round edge without the need to flip the box and take out the necessary pills. This reduces pill handling and reduces the time in which a person takes their pill.

3. Air tight closure:

The primary packaging of pills in which we buy them in whether bottled or blister packs, is designed so that the pills can have the right environment, therefore when removed from their original package the same safe environment should be kept constant. Therefore, an air tight seal ensures that the pills are not exposed to air and moisture.

4. Opaque Plastic:

This feature is also important to protect the pills, as it does not allow the light to enter.

5. Rounded outer edges:

Looking at design trends in 2021, rounded sleek and smooth forms are being more used. In a study, it was proven that the human brain conditions sharp edges with harm, although the pill box cannot be harmful if not rounded the rounded edges create a more modern and friendly feel. Moreover, rounded edges are visually appealing and therefore this feature solves the issue of unattractive pill organizers.

3.2.2. Design Idea 2:

This design focuses on the idea of catering for different users both occasional and regular users.

Design features:

1. Modular design

The detachable and attachable compartments allow the users to decide how many compartments do they need according to their medication schedule. Furthermore, it allows the person to control the number of times they want to refill, for example if someone takes pills everyday of the week and purchases 14 different compartments they can refill once every two weeks rather than every week or every day.

The detachable feature also allows for easier portability as the user can grab the compartment that is needed for the day and not carry all the other compartments that are meant for other days.

2. Triangle shape:

this feature allows the compartments to be organized in different formations according to the users' preferences and place they are storing their compartments *(refer to figure 3.2.2.1).* The triangles are flat at least on two sides therefore the user can place them flat on a surface or standing up.

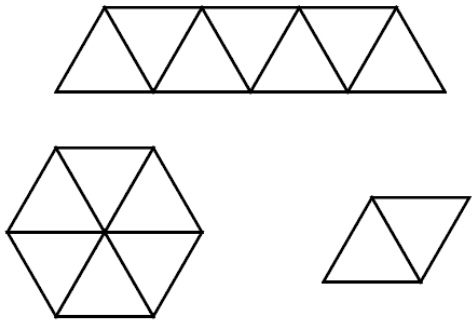


Figure 3.2.2.1: different formations of triangle pill box compartments (Made by Author)

3.2.3. Design Idea 3:

This design presents a creative way for having different number of compartments as the stand length adjusts according to the number of compartments present.

Design features:

1. Expandable stand

This allows the user to purchase the stand as as many compartments needed for their medication regime, and also add compartments if needed in the future. (the stand can fit up to 8 compartments)

2. Pill Shaped form:

An extra visual element where the form of the pill compartments and the stand form a pill shape no matter how many compartments are added on the stand.

3.3. Final Plan

After analyzing the design variations, the chosen design is design number 1 due to its simplicity and range to suit both occasional and regular users.

3.3.1. Analysis of design 1:

The first design offers a great solution especially for occasional and regular users but especially for users who take many pills (7+) as they could see all their pills and easily reach and grab the required pill at the required time. The 4 sections of morning, noon, evening and night accompanied by the application provide a good solution for not confusing similar looking pills and thus reducing the risk of complications. As for the occasional user 1 pill box can be bought rather than 7 and the 4 compartments can be used for different days as there is not much pills to take and therefore no need for the extra pill boxes.

3.3.2. Analysis of design 2:

Having detachable compartments, that can be sold separately suits the occasional user's lifestyle and the regular user. If a person takes a small number of pills on certain days of the week, they would benefit from having less compartments, or smaller compartments as the pills wont stack since there are not many. The compartments can also be carried easily and separately which also caters for the occasional users need and does not force them to carry a whole week's number of pills for one day out. As for the regular user many compartments can be bought and attached to each other to suit their need. This is a great solution however it can be complex, and from the user experience in section 2.1 it is deduced that users prefer simpler easy options.

3.3.3. Analysis of design 3:

The compartments in this design would have to be deeper but smaller, similar to the existing pill box designs, which means the pills would be stacked on top of each other and have to be removed in order to reach the desired pill. Moreover, extra handling of the pills will occur which might pose the risk of dissolving of pill or bacteria surrounding the pill. Small compartments were also an issue for users especially occasional users as some vitamins and supplements won't fit since they are bigger than other pills. In addition to that, the idea of an expandable stand seems complex for a pill box and might not suit the user, a simpler solution is preferred which can be seen from their choice of using the 7-day plastic pill box.

Mood Board

Figure 3.4.1: Mood-board (Made by Author)

The mood board captures the style of the pill box design mainly sleek modern design with rounded edges. It also showcases the three main users of the pill box, occasional healthy users who use it for vitamins and supplements, elderly people, and caregivers who take care of elderly people. This design aesthetic is timeless, for example the yellow and white cube in the mood board is a design from the 1970's by Sony which can easily be mistaken to be a design from our current time.

The main idea is that the design should be simple and timeless fitting into more than one user's lifestyle.

3.4. 3d Visualization

3.4.1. Pill Box Version 1

Figure 3.4.1.1: Pill box Renders (Made by Author)

The features from section 3.3.1 are present in this design making it a simple yet efficient solution for the identified problem. Additionally, this version of the product is directed towards the younger occasional user who might still have kids. Hence, it is child proof in the sense that opening is not obvious for a kid and is slightly harder to open; the user must push the lid from the spot that has ridges giving them a good grip and more friction to make it easier to open. Also, to prevent the illustrations and letters of the days from being scratched off, they are engraved in the box allowing them to last longer and not cause confusion.

To top that, the illustrations and days of the week are subtle to keep the design minimal and also to allow the younger user to take it to the workplace or display it on the counter while maintaining professionalism.

3.4.2. Pill Box Version 2

Alternatively, these features might not suit the elderly. It is common among the elderly to have joint diseases and therefore require a box that opens easily. It is also common that the vision become weaker and therefore more contrasting and bigger illustrations and letter should be used to eliminate confusion and errors.

Arthritis:

It is a disease that usually affects people with age, as their joints become weaker and get inflamed or tart to degenerate causing pain and limited range of motion in the area that is affected.

People with arthritis, depending on the severity have to adjust their daily activities to reduce the tension on the joints. Product design solves some of the difficult tasks by creating adaptive equipment's to simplify a patient's daily activities and reduce stress on joints. [32]

According to an arthritis researcher Helen Hurman, people with arthritis do not feel comfortable using products that are modified to their needs but look medical, bulky and different, on the contrary they would like product that feel comfortable for both their joint and their eyes. [33]

[32] Cleveland Clinic medical professional. (2021, April 15). *Arthritis: Symptoms, Types, Causes & Treatment*. Cleveland Clinic. Retrieved November 16, 2021, from https://my.clevelandclinic.org/health/diseases/12061-arthritis

[33] *Why designing for Arthritis makes commercial sense*. (2017, November 3). Design Council. Retrieved November 15, 2021, from https://www.designcouncil.org.uk/news-opinion/why-designing-arthritis-makes-commercial-sense

Weak Vision:

With age the eyesight can become weaker, there are several eye problems that can occur with older age these include Presbyopia, Dry eyes, and cataracts. Some common symptoms of the following include some loss of vision or blurry vision, not being able to see small prints or to read from close. [34]

Design wise, there are certain factors that should be taken into consideration when designing for seniors with visual impairments. First and foremost, is the size and font type used. San-serif fonts are ideal for seniors as letters are more legible without the serifs. Bigger sizes are also better and more readable for the older user. Secondly the color contrast. It is important that the contrast between the background and the text is high so that its more readable, if the hues were too close to each other the difference between them might not be visible. [35]

For that reason, the second version of the pill box should have contrasted and clear lettering and illustrations in addition to having an easier opening mechanism that is comfortable for arthritis patients. Keeping in mind that the box should still look representable and appealing.

3D models:

Figure 3.4.2.1: Pill box version 2. (Made by Author)

[34] Cleveland Clinic medical professional. (2021a, April 15). Aging Eyes: Vision Changes & Common Problems. Cleveland Clinic. Retrieved December 1, 2021, from https://my.clevelandclinic.org/health/articles/8567-common-age-related-eye-problems

[35] Hughes, M., D., & McGinnis, L. (2010, May 17). Designing for Senior Citizens | Organizing Your Work Schedule. UXmatters. Retrieved November 15, 2021, from https://www.uxmatters.com/mt/archives/2010/05/designing-for-senior-citizens-organizing-your-work-schedule.php

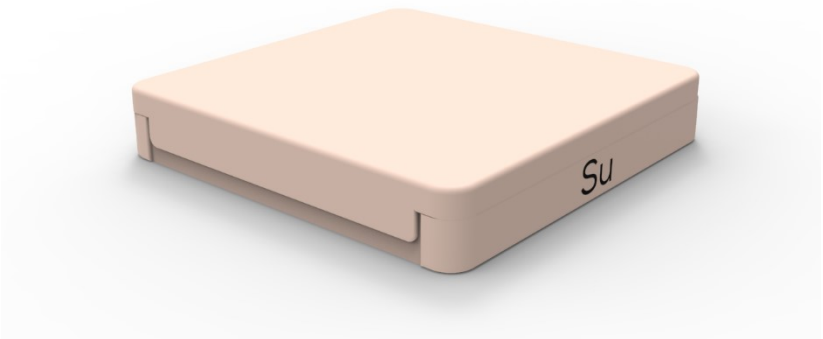


Figure 3.4.2.2: Easy open pill box version with high contrast engraved Letters.
(Made by Author)

The pill box version is easier to open to reduce stress on joints. It also has San-serif high contrast letters for people with weaker vision. The box will be available in different colors giving the user the choice between neutral colors, or colorful options .

Figure 3.4.2.3: Pill box version 2 colorful. (Made by Author)

3.4.3. Pill Box Holder

The Pill box holder has mainly two functions, to hold all the boxes together so that they are not scattered around the house and lost, and also to hide the boxes from guests, children, or simply for aesthetic purposes. It can hold up to 7 boxes each for a day of the week, however for non-daily users the boxes can be sold separately without the holder.

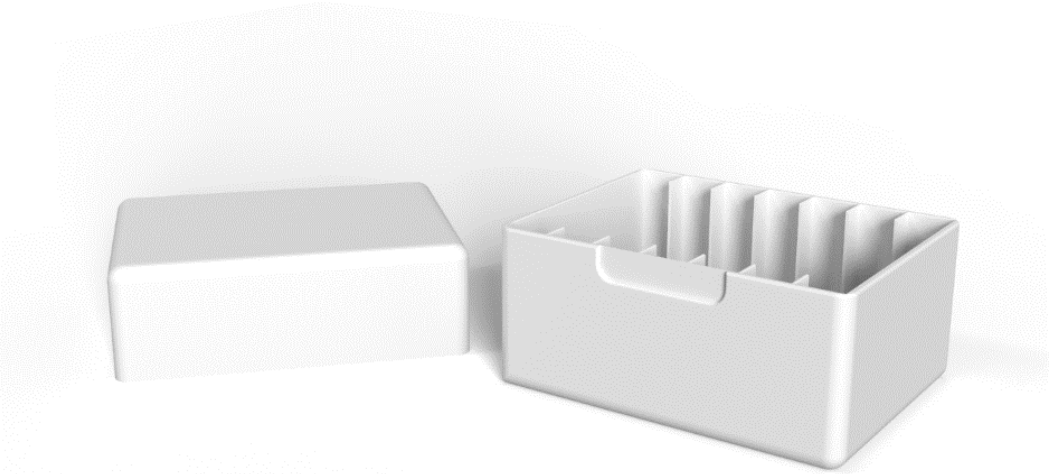


Figure 3.4.3.1: Stand that fits 7 pill boxes shown to have slits on the inside to hold the boxes in place.

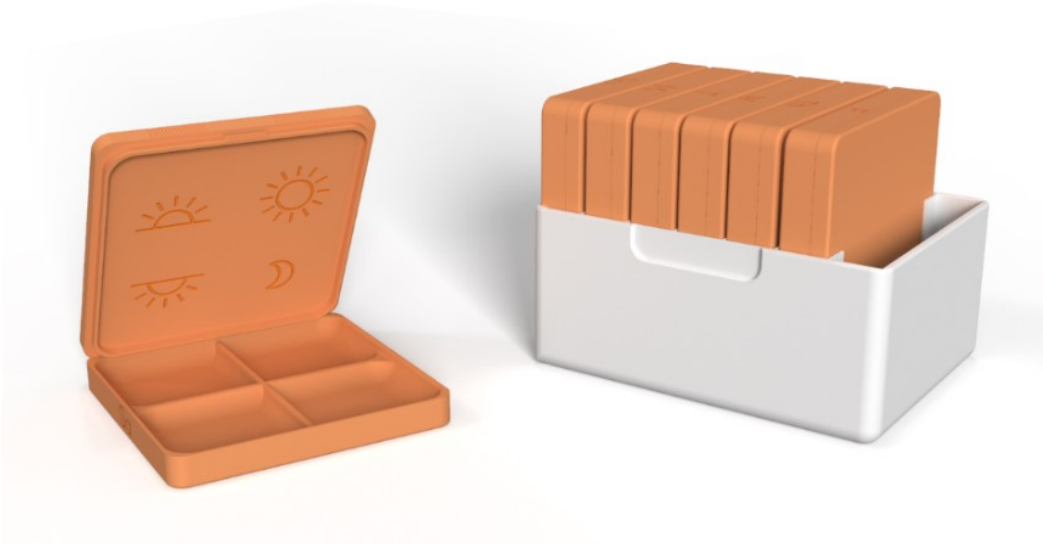


Figure 3.4.3.2: Demonstration of how the stand will carry the pill boxes allowing for easy grabbing of the boxes.

[36] Creative Mechanisms Staff. (2016, May 4). *Everything You Need To Know About Polypropylene (PP) Plastic*. Creative Mechanisms. Retrieved December 1, 2021, from https://www.creativemechanisms.com/blog/all-about-polypropylene-pp-plastic

3.5. Application Design

Figure 3.5.1: Launch Screen of the app. (Made by Author)

The application's name is HippoCampus which is the part of the brain that retains information and makes us remember, thus this app will retain all the information about the different medications and remind the user. In Greek, the word hippocampus means seahorse, which was the inspiration for the logo; a seahorse but the body is made out of a pill as it is a medication app.

Figure 3.5.2: Home page (Made by Author)

The home page is the page which has the basic necessary info for the user including the pills remaining for the day and the pills they already took. It is also customizable, if a user takes blood pressure medication and has to keep measuring their blood pressure, they can have the blood pressure widget. Or if a person needs to drink more water, they can keep the water widget and record their water intake.

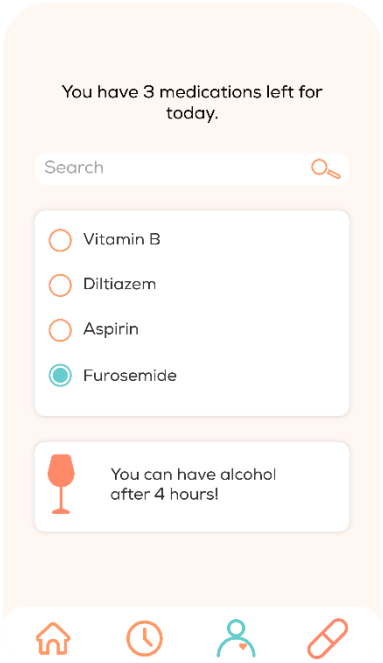


Figure 3.5.3: Medications Page (Made by Author)

The medications page shows the detailed list of the medications that the user takes and if a medication is clicked more information can be seen for example the prescription information which will appear using a medication API. Moreover, it would show the user important notes such as eating before the pill, or not mixing their pill with alcohol.

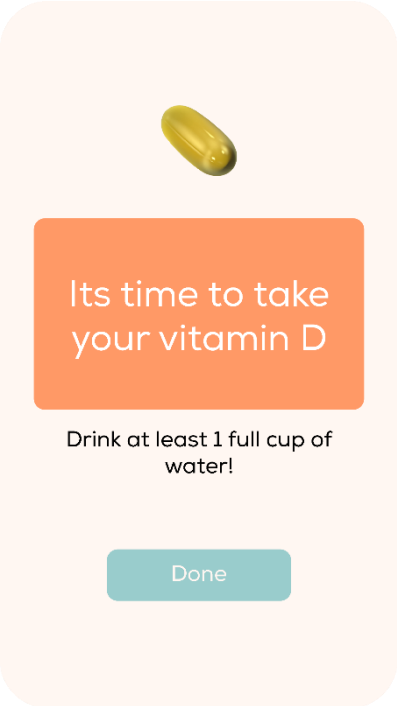


Figure 3.5.4: App Reminder when notification has been clicked

When it is time for the user to take their medication, they would receive a notification reminder. When they click the notification, they could see the image of the pill to help them take the right pill out of the box, along with any important prescription information such as drinking more water with this medication to protect the kidneys, or eating proteins to increase the effectiveness of a certain medication.

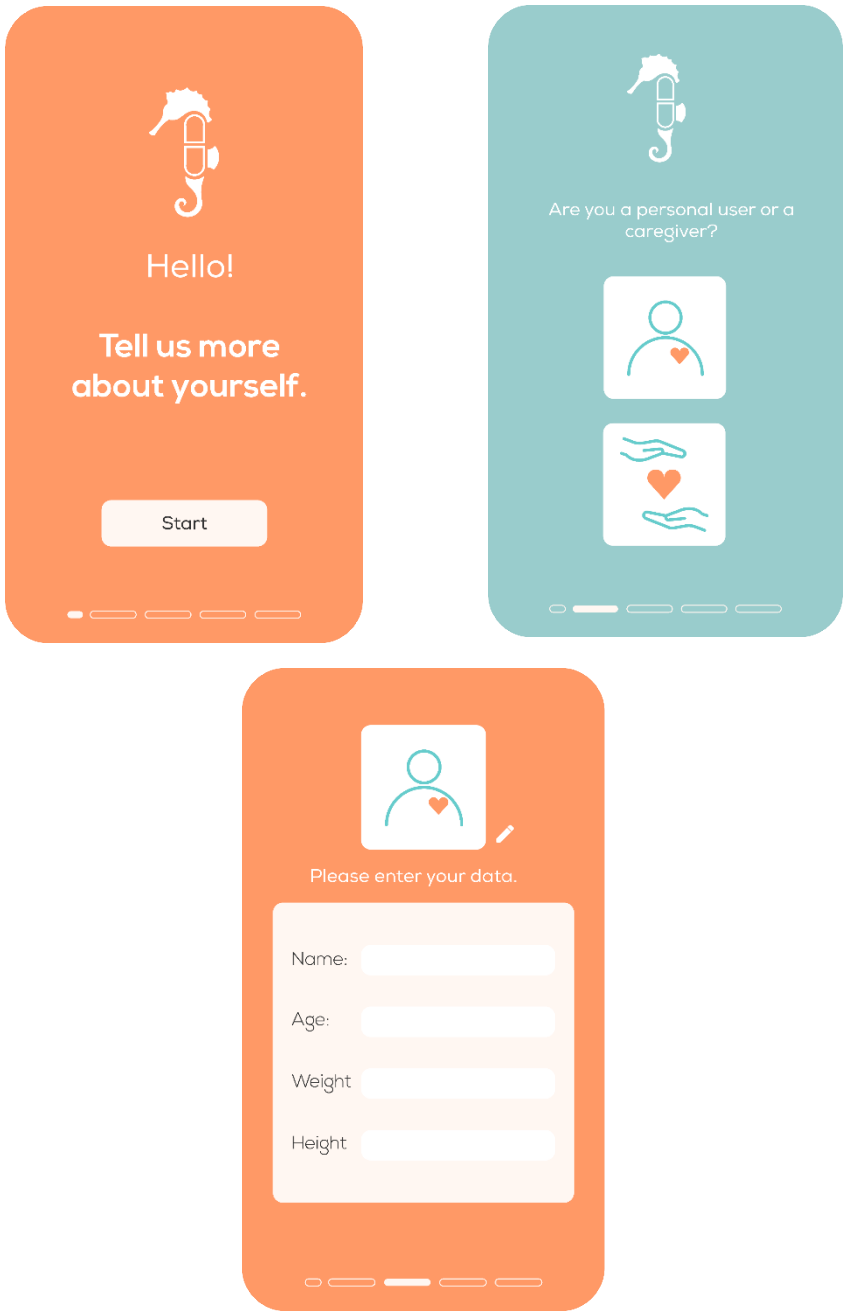


Figure 3.5.5: Data Entry pages when the user first downloads the app. (Made by Author)

The application can be used by a person who keeps track of their own medication or by a caregiver to make sure the client adheres to their medication.

3.6. Technical drawing

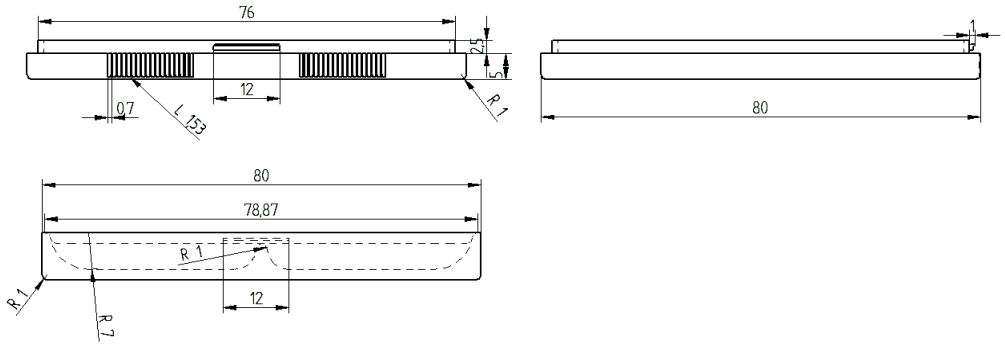


Figure 3.6.1: Pill box version 1 (Made by Author)

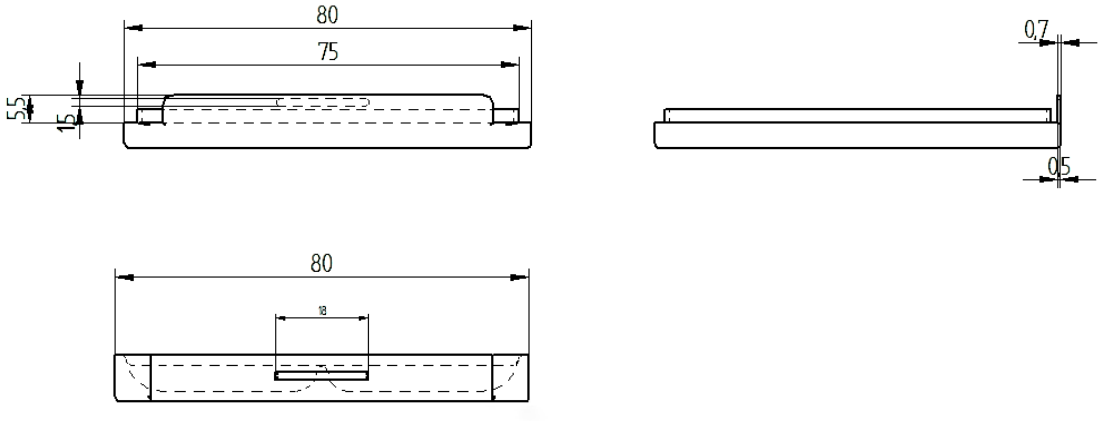


Figure 3.6.2: Pill box Version 2 (elderly) (Made by Author)

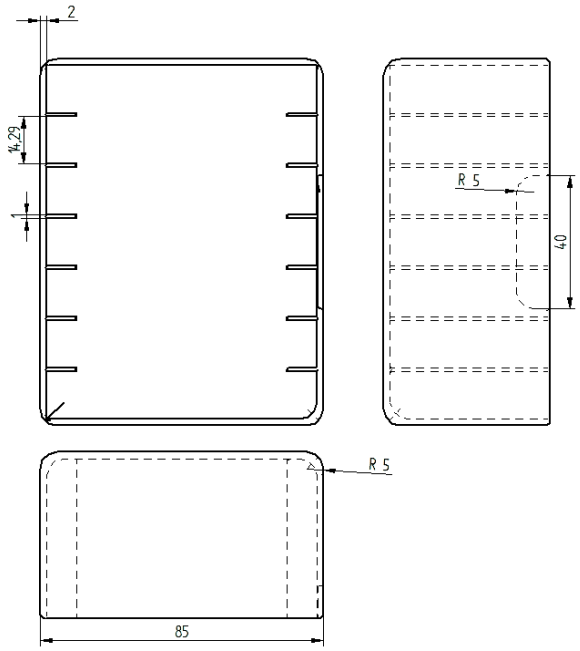


Figure 3.6.3 (a): Pill box stand that holds 7 pill boxes. (Made by Author)

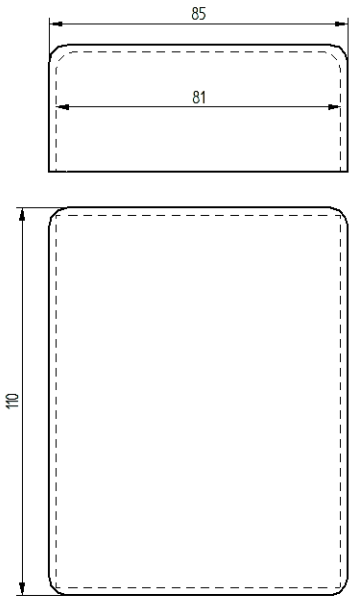


Figure 3.6.3 (b): Pill box stand lid. (Made by Author)

3.7. Material Study (images of worn-out box)

Intensive research was conducted to choose the optimal material for the pill box taking into consideration the following factors:

- **Durability:** the pill box is an item that would be used on daily basis and would be carried around; therefore, the material should be able to handle that and not be worn out easily.
- **Opacity:** the material should not allow light in as it can interact with the chemical composition of some medications, therefore the material chosen should be opaque and not transparent.
- **Moisture resistance:** some pills might dissolve or be altered when subjected to moisture therefore the material of the pill box should be moisture resistant as to protect the pills.
- **Toxicity:** the material used should be food grade and shouldn't include any intoxicating substances as it holds pills that will be adhered by people.
- **Sustainability:** keeping sustainability in mind while choosing the material is important to reduce the impact this product would have on the environment.

Four materials were examined in order to choose the best material that follows all the requirements in order to safely and efficiently carry pills. These materials include Polypropylene (PP), Polycarbonate (PC), Acrylonitrile Butadiene Styrene (ABS) and Bamboo Wood.

3.7.1. Polypropylene (PP)

PP is a flexible type of plastic which is commonly used in medication boxes mainly due to its safety as it does not contain bisphenol A (BPA). It is a thermoplastic meaning it can be remelted into liquid form as many times and injection molded to form new objects. This makes it recyclable unlike thermoset plastics which cannot be heated more than once or else they will burn.

In 1952 a pair of petroleum scientist first polymerized PP in 1951, and was later perfected by Giulio Natta. From then on, the its production and use became famous. This trend remains until today where PP is one of the most commonly used plastic around the world and a major part of the production is for packaging purposes.

As any other material, using PP has advantages and disadvantages. Some of the advantages which are related to using it for a pill box include:

1. Water Resistant

It has a low coefficient of friction which means it's extremely slippery and hence it is a great moisture resistant material. This is a great property as pills should be kept out of moisture.

2. Durable

It has good impact strength which is important for a pill box as it will be used daily and should last long for sustainability reasons. It will also be portable and therefore it should not break during travel.

3. Manufactured into Living Hinges

Living hinge is a part that is connected to the lid and the body of a plastic container which bends to rotate the lid and open the container. It is a thin layer of plastic that can withstand being bended on high angles without breaking. PP Living hinges can be manufactured by both injection molding and Computerized Numerical Control (CNC).

They can be useful in a pill box as it will make the production easier rather than producing two parts and connecting them. One concern would be the strength of the hinge, since the pill box would be opened several times a day and also on weekly basis therefore the thin piece of plastic might break due to constant

4. Inexpensive

This is an important feature since the best seller pill boxes on the market are the simpler and cheaper options. Using PP, would keep the price of the box in a range that can be suitable for a larger number of audiences.

5. Good Chemical Resistance

This is an important feature for the safety of the people, as no chemicals would leach from the material.

Nevertheless, it has a disadvantage of having a low Melting Point. This means that it is relatively difficult to machine and it melts quickly from cutters and other machinery. [36]

3.7.2. Acrylonitrile Butadiene Styrene (ABS)

ABS is another example of a thermoplastic that is used in the manufacturing of pill boxes. Therefore, similar to polypropylene it can be recycled, and hence one way of producing ABS is from other ABS plastic. ABS is considered by the Food and Drug Administration (FDA) to be food grade although it not resistant to all chemicals yet the leaching is not considered harmful according to the FDA's standard therefore is it food grade and used in products such as Lego's and food processors. However, the general public considers it harmful as leaching might occur and prefer to use another plastic. [37]

Some ABS advantages include:[38]

1. **Inexpensive**

Which means the pill box could be sold at a lower price.

2. **Impact resistant**

ABS is really strong, even stronger than PP, that is why it is commonly used in packaging.

3. **Resistant to corrosive chemicals**

It is generally resistant to chemicals however not as much as PP is resistant, which is one of the reasons people worry about using it.

4. **Easy to Machine**

Unlike PP, ABS is easy to machine and the result are usually smooth and clean. This is why ABS products have a high-quality aesthetically pleasing appearance.

ABS is considered harmless as it does not include any known carcinogens- cancer inducing substances- and it is FDA approved as food grad material. However, some believe ABS can be toxic especially when being produced as it has a strong smell and can nausea and dizziness. [38]

[37] Trombetta, D. T. (2016, June 16). *The Tricky Business of Choosing Plastic for Food Contact Applications*. WordPress.Com. Retrieved December 1, 2021, from https://weeklypellet.com/2016/06/10/the-tricky-business-of-choosing-plastic-for-food-contact-applications/

[38] Rogers, T. (2015, July 13). *Everything You Need to Know About ABS Plastic*. Creative Mechanisms. Retrieved December 1, 2021, from https://www.creativemechanisms.com/blog/everything-you-need-to-know-about-abs-plastic

3.7.3. Polycarbonate (PC)

Polycarbonate plastic is a naturally transparent thermoplastic, that is recyclable. It was first developed in the 20th century By GE in the United States of America and Bayern in Germany.

Because of its translucent properties it allows light to pass almost as well as glass. It is usually used as a substitute of glass as it is lighter and more durable unlike glass which can break easily. They are robust plastics that can withstand heavy impact and is even stronger than ABS, the strength in comparison to other materials can be seen in figure (3.5.4.1). Yet, although they are highly impact resistance they tend to scratch easily unless an anti-scratch coating is applied. [39]

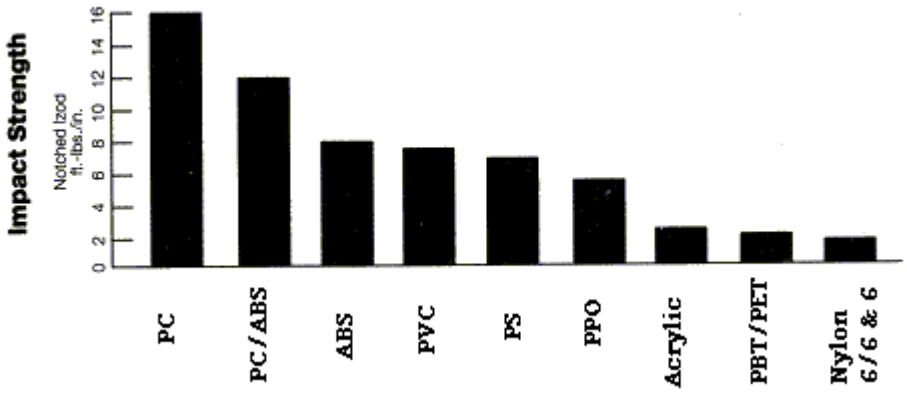


Figure 3.7.3.1: Shows the impact strength of PC in comparison to other plastics [40]

A common application of PC Is in eyewear as it is a natural UV filter.

Some types of PC plastics can pose health risks when in contact with food as they release Bisphenol A (BPA), yet some BPA free options are also present which are commonly used for liquids and foods which spoils in a short time. [39]

[39] Rogers, T. (2015b, August 21). *Everything You Need To Know About Polycarbonate (PC)*. Creative Mechanisms. Retrieved December 1, 2021, from https://www.creativemechanisms.com/blog/everything-you-need-to-know-about-polycarbonate-pc

[40] [Shows the relative impact strength of Polycarbonate when compared to the impact strength of other commonly used plastics]. (n.d.). Ptsllc. https://ptsllc.com

3.7.4. Bamboo Wood

Bamboo has become a common material used in eco-friendly products to substitute plastic. Its main strength point is that it grows quickly and can mature from 1-5 years depending on the species, making it the fastest growing tree. Another important advantage is that it does not require a lot of care to grow nor a lot of Pesticides, and requires only a little water to grow. It is a renewable material that also benefits the environment when grown as it absorbs the most amount of Carbon Dioxide (CO2) and releases 35% more oxygen compared to a tree with the same mass.

It mainly grows in tropical climates in southeast Asia, Africa, Latin America and southern regions of the United States.

Another property of bamboo is that it has extremely high strength even stronger than steel, with a tensile strength of 28,000 PSI in comparison to steel's tensile strength of 23,000 PSI and is therefore used to build huts and houses in some countries.

On the other hand, as bamboo demand is increasing farming problems are occurring, and one major problem is deforestation and loss of biodiversity. In order to make room for more bamboo growth other diverse forests are being cleared to plant bamboo therefore threating the wildlife and habitat of the diverse species in that area. Especially that bamboo is often planted as a monoculture which means all other varieties are removed from that area to plant bamboo crops. This gives rise to many environmental problems including the destruction of diverse ecosystems which leads to the negative effect on different species including bacteria, insects and other animals who require to live in a certain habitat and have the necessary nutrients. [41]

[41] Carter, B. (2021, April 13). *Truth or Trend: Is Bamboo Sustainable?* Eco & Beyond. Retrieved December 2, 2021, from https://www.ecoandbeyond.co/articles/is-bamboo-sustainable/

Another setback, is that currently bamboo products all around the world are produced in China, the only place where bamboo production is on a commercial scale. This means the products have to be shipped across countries adding to the carbon footprint, hence reducing the environmental advantages of using bamboo and might even favor locally produced plastic over it.

This also poses the risk of unethical and below standard farming practices since China does not enforce strict agricultural and environmental standards. These practices could include the use of chemical pesticides and fertilizers in order to increase yield and speed at which the bamboo grows, which is unnecessary as bamboo already grows at a fast rate. Thus, the increasing demand of bamboo products over the years *(refer to figure 3.8.4.1)* could lead to habitat destruction making the choice of bamboo over other material not justifiable.

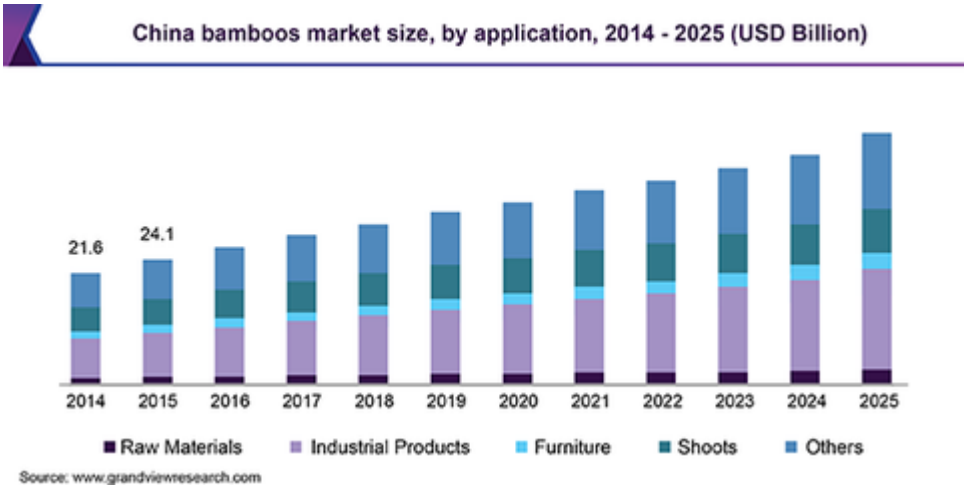


Figure 3.7.4.1: Bar chart showing China's bamboo market size starting 2014 and predicting 2025.[42]

[42] China's Bamboo Market. (n.d.). [Graph]. Ecoy. https://cdn.shopify.com/s/files/1/0498/6100/1367/t/3/assets/pf-d32bfe96--chinabamboosmarket480x480.png?v=1619215149

Additionally, bamboo products are can grow mold if they are in contact with water for a long time unlike other materials such as plastic which has a slippery surface making it water resistant.

Finally, although bamboo has a high tensile strength in its raw plant form, when it undergoes the production process it becomes fragile, which means the products last a shorter time and have to be replaced. For example, reusable bamboo coffee mugs were becoming popular until people realized they are not as durable in comparison to plastic cups which can be used for a long time. This is especially a problem, as replacing a bamboo product with another bamboo product means that it has to be shipped from China more often hence negatively impacting the environment. This poses the question of whether bamboo products are actually a more sustainable more sustainable option or not.[41]

3.7.5. Final Choice

After reviewing the advantages and disadvantages of all the materials mentioned above the final material choice would be polypropylene. The reasons are outlined below.

It is a durable, water-resistant material that can be produced to be opaque making it light resistant as well, which is the perfect combination for a pill box to keep the pills in the right conditions.

It is also recyclable as it is a thermo plastic, and 31% of plastics are recycled in Hungary and that percentage is increasing.

ABS is also durable and water and light resistant however some studies show that it might leach toxic material and people have a negative perception on it even though it is FDA approved. This could lead to lower sales due to the material used. Moreover, when ABS is polymerized, it releases a gas that is not considered dangerous but it's warned to cause nausea and dizziness giving the people a stronger proof that ABS can be toxic.

As for Polycarbonate, although it would look elegant due to being viewed as glass, yet it allows light to pass easily to the pills and usually pill boxes which use this material have an outer casing to protect it. Therefore, this material was not chosen.

Lastly, Bamboo although can be environmentally friendly and also luxurious in comparison to plastic yet it has two main problems. First, it does not have a proper closure, some pill boxes made of bamboo already exist on the market and most of the reviews point out the problem with the closure and how well it contains the pills. *(Refer to figure 3.8.5.1)*

Figure 3.7.5.1: Bamboo Pill box with magnetic closure.[43]

Another major issue is that technically bamboo would not be environmentally friendly in comparison to PP plastic in this case because Hungary does not produce Bamboo products on a commercial scale and therefore it would need to be manufactured at another place, whereas producing the pill box by injection molding in Hungary would reduce the carbon footprint associated with transportation and shipping.

[43] Bamboo Pill box. (n.d.). [Photo]. Shopify.
https://cdn.shopify.com/s/files/1/0291/9733/6681/collections/picture8.png?v=1588018848

3.8. Manufacturing, Selling and Recycling

3.8.1. Production

The pill boxes will be produced using injection molding, which is a common method of producing plastic parts. [44] Injection molding involves an injection molding machine that melts the plastic and injects it into a mold. then it is cooled down to have the final product. However, after that process usually additional processing is required to perfect the product and remove any excess material, this material can then be recycled to make other products in the case of using PP plastic.

Ideally the production could be in Hungary as to reduce transportation costs and minimize the carbon footprint. There are several Manufacturing plants that specialize in Injection molding of plastic and specifically polypropylene in Hungary. One example is Plasticor which is 100% Hungarian owned, with a plant dedicated for injection molding in Veszprém.[45]

3.8.2. Distribution methods

In the beginning as it is still a new product it would be easiest to sell it online. The initial target would be to sell it in the Hungarian market, then growing to delivering to European countries. Therefore, the packaging design for the pill boxes will satisfy the requirements of delivery.

Some pill boxes can also be sent for at famous pharmacies in Budapest.

[44] Injection Molding Process, Defects, Plastic. (n.d.). CustomPartNet. Retrieved December 3, 2021, from https://www.custompartnet.com/wu/InjectionMolding

[45] B. (2020, June 20). *Get to know us*. Plasticor. Retrieved December 3, 2021, from https://www.plasticor.hu/en/introduction/

3.8.3. Recycling plants

After the product is produced and sold and used for a long time by the users all efforts should be made to make sure the they are not thrown into landfills. The products are completely made out of PP plastic which allows it to be easily recycled as all parts can be remelted and remolded. Therefore, the packaging will indicate clearly that the product can be recycled, and also there is an option to return the product to the company as they would take care of the recycling of the old boxes, in case there are no collecting bins nearby.

The percentage of plastic recycling in Hungary is increasing, this provides an opportunity for the boxes to be recycled [46] There are many recycling plants in Hungary that recycle plastic, specifically PP, mostly turning them back into pellets to be used in injection molding. Some examples or recycling companies include B Pack Kft., Biors Hungary kft, Herner-Plast Kft., Holofon Zrt., …etc. [47]

[46] Kató, A. (2019, June 14). How close is Hungary to hitting its recycling target? Daily News Hungary. Retrieved December 2, 2021, from https://dailynewshungary.com/how-close-is-hungary-to-hitting-its-recycling-target/#:%7E:text=The%20state%20of%20plastic%20recycling,Hungary%20currently%20stands%20at%2031%25.

[47] Plastic Recycling Plants In Hungary - ENF Recycling Directory. (n.d.). ENF Recycling. Retrieved December 2, 2021, from https://www.enfrecycling.com/directory/plastic-plant/Hungary

4. PACKAGING

4.1. Packaging Plans

4.1.1. Single packaging

This is packaging option for the user who would purchase only 1 pill box or a number of boxes but nor for a whole week, mostly for the occasional user or for someone who loses their box and have to replace it for any other reasons.

1. Packaging Plan 1:

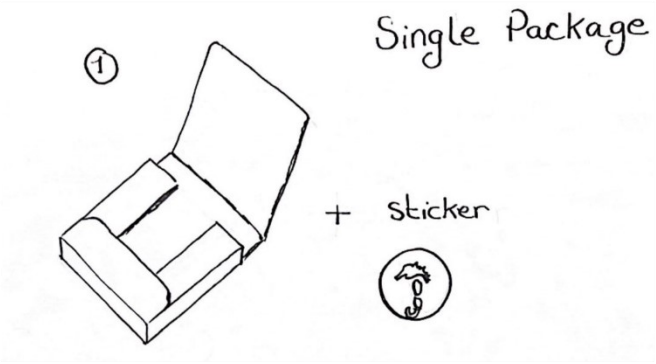


Figure 4.1.1.1: Sketch of Packaging for a single box. (Made by Author)

The first plan is a simple corrugated box which locks with a sticker with the logo of the brand. This is a sufficient packaging option as its durable, sustainable and easy to deliver as it does not take space and its stackable. It would protect the pill box and also offer a good quality package for the consumer to open.

[48] W. (2019, July 8). The Ultimate Guide To Corrugated Boxes. Shorr Packaging. Retrieved December 2, 2021, from https://www.shorr.com/resources/blog/ultimate-guide-corrugated-boxes/

[49] propac. (n.d.). Understanding Corrugated Flutes | Professional Packaging Systems. Retrieved December 2, 2021, from https://www.propac.com/packaging-materials/corrugated-shipping-cases/understanding-corrugated-flutes/

2. Packaging Plan 2:

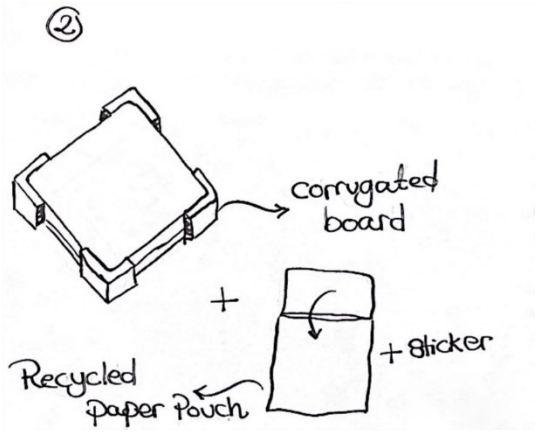


Figure 4.1.1.2: Sketch 2 of packaging for single box.
(Made by Author)

This packaging plan reduces the amount of packaging needed. Since the pill box is made out of durable plastic that is moisture resistant and can handle impact not much packaging is needed therefore reducing the packaging can have a positive impact on the environment and also cost wise. The pill box will only be cover by durable corrugated board from the 4 sides which would protect in case of impact. The box along with the corrugated edges are then placed a thin recyclable paper pouch mailer to protect it from scratches, dirt and moisture.

4.1.2. 7-day pill box Packaging

There will be two packaging solutions one package is meant to hold 7 pill boxes, and the other package is meant for users who decide to purchase the 7 pill boxes along with their stand. This offers a sustainable option for users who do not want to purchase the extra plastic stand.

1. Package For Pill boxes without stand:

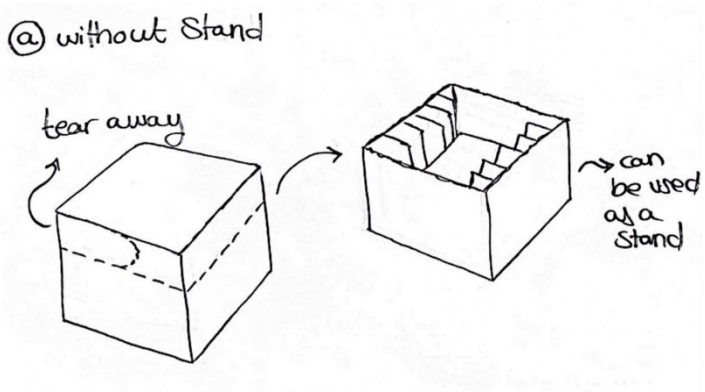


Figure 4.1.2.1: Sketch of Packaging of 7 pill boxes, without their stand. (Made by Author)

This design would be made out of corrugated board which is durable for delivering the pill boxes. It also has a tear away strip and inner separators which allows the user to use the bottom part as a pill box stand which can be placed in drawers, medicine cabinets…etc. This is a sustainable choice over purchasing the plastic stand particularly for people who would not display their pill boxes on a counter but hide in a drawer or cabinet. Only the top part and the tear away strip would be single use however it is recyclable and can be made from recycled materials.

2. Package for pill boxes with stand:

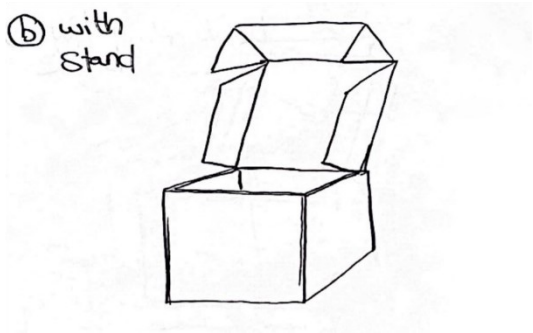


Figure 4.1.2.2: Sketch of packaging of 7 pill boxes and their stand. (Made by Author)

This corrugated box is for packaging 7 pill boxes and the plastic stand. It is a simple yet high end box which ensure the safety of the product inside while also being completely recyclable and ecofriendly.

4.2. Material

The material chosen for all the packaging variations is corrugated board. It is the best option since it will protect the product during delivery as it is made of several layers.

The board type will be single walled which is sufficient to protect the pill box or the stand during delivery. [48]

As for the flute type, E-flute will be used in all packaging with a thickness of 1.5mm. It is the optimal choice as it is crash resistant and also has a smooth surface that can allows for high quality printing.[49]

[48] W. (2019, July 8). The Ultimate Guide To Corrugated Boxes. Shorr Packaging. Retrieved December 2, 2021, from https://www.shorr.com/resources/blog/ultimate-guide-corrugated-boxes/

[49] propac. (n.d.). Understanding Corrugated Flutes | Professional Packaging Systems. Retrieved December 2, 2021, from https://www.propac.com/packaging-materials/corrugated-shipping-cases/understanding-corrugated-flutes/

4.3. 3D visualization

4.3.1. Group Packaging (7 pill boxes)

Figure 4.3.1.1: Corrugated Box with tear away feature (Blue line) to be reused as a holder. (Made by Author)

Figure 4.3.1.2: Back side of the Tear away package. (Made by Author)

All the information and design elements are on the top part so that when its teared away the stand remaining is a simple white stand. (Refer to figure 4.4.3.3)

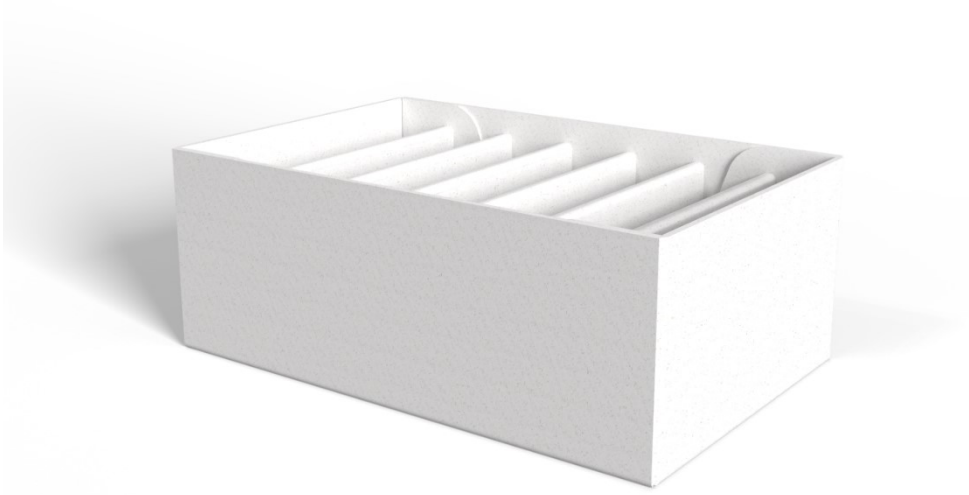


Figure 4.3.1.3: Corrugated box after its was torn off. (Made by Author)

The box can be reused as a stand

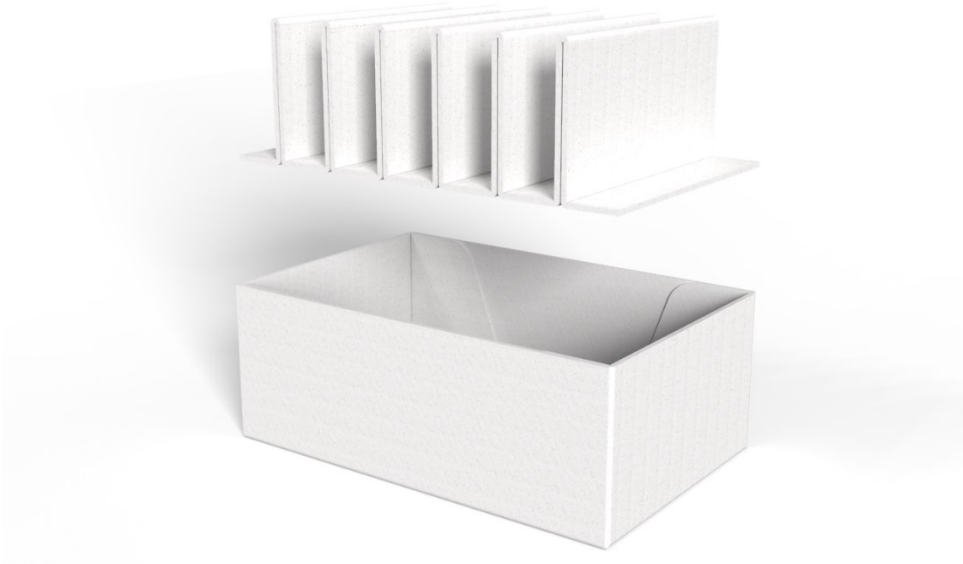


Figure 4.3.1.4: Demonstrating the partition that holds the pill boxes.(Made by Author)

4.3.2. Group Packaging (7 pill boxes) with Stand

Figure 4.3.2.1 Mailer box to package stand and pill boxes. (Made by Author)

Figure 4.3.2.2: Mailer box showing side design and QR code for application. (Made by Author)

Figure.4.3.2.3: Packaging for pill boxes with stand closed. (Made by Author)

4.3.3. Single Packaging (1 pill box)

Figure 4.3.3.1: Box for a single Pillbox closed with a sticker. (Made by Author)

Figure 4.3.3.2: Box for a one Pillbox, opened, showing the design from the inside including QR code for the application

Figure 4.3.3.3: Package for one pillbox, with traceability information and recycling icon. (Made by author)

Figure 4.3.3.4: Top view of box opened. (Made by Author)

4.4. Technical Drawing

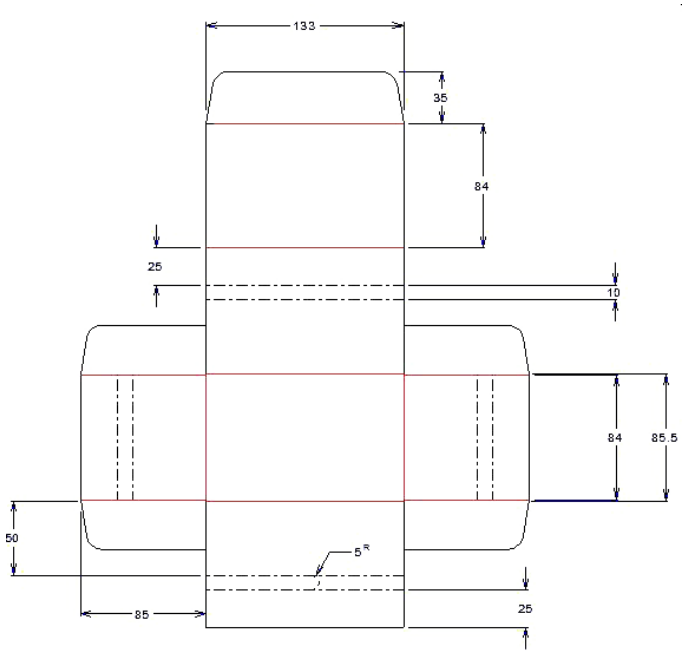


Figure 4.4.1: Technical drawing of tear-off stand box to package 7 pill boxes without their stand. (Made by Author)

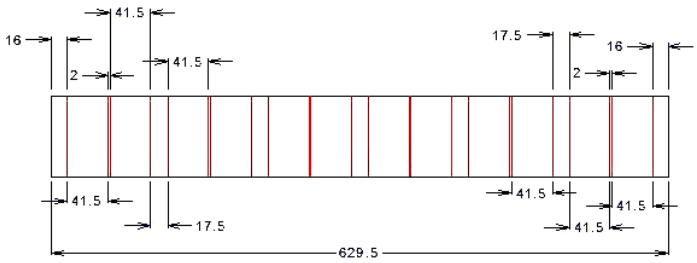


Figure 4.4.2: Technical drawing of partitions for the packaging of pill boxes without their stand. (Made by Author)

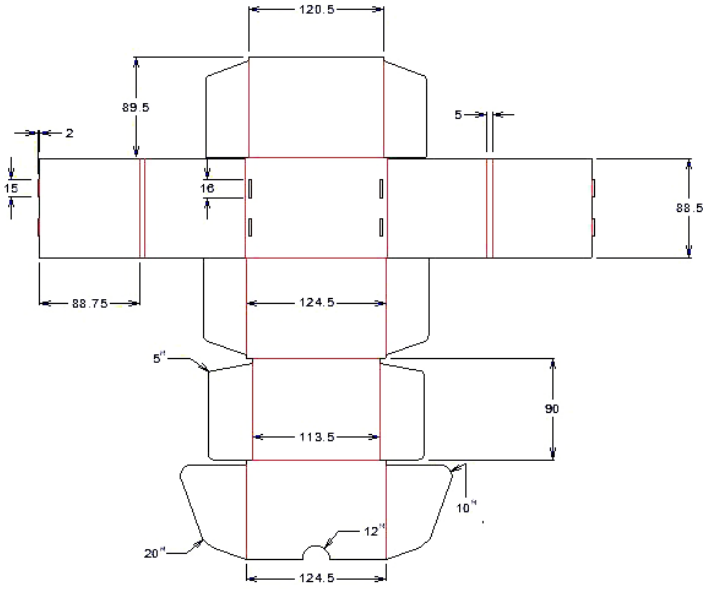


Figure 4.4.3: Technical drawing of the packaging for 7 pill boxes and their stand. (Made by Author)

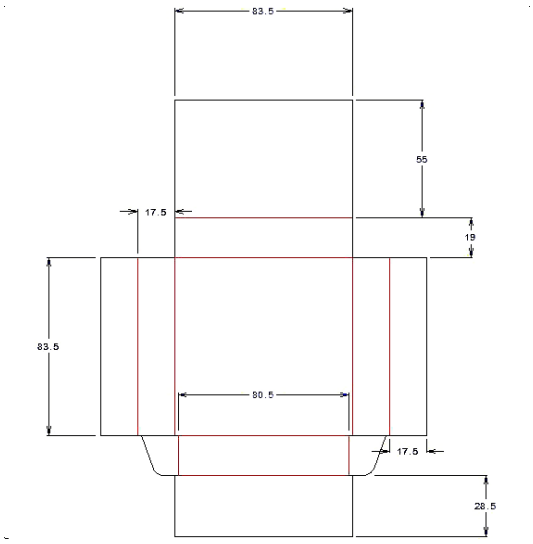


Figure 4.4.4: Technical drawing of packaging for a single pill box. (Made by Author)

5. COST CALCULATION

Cost estimation of the materials of the packaging products can be deduced based on a corrugated sheet price in Hungary

választ	megnevezés	kód	hmotnost	Ár ÁFA nélkül	Ár ÁFÁ-val
◉ A	világosszürke/természetes fehér, méret 100 x 172 cm, vastagság 1,6 mm, súly 560 gsm, felületi súly 190 gsm	KL021104		4 145 Ft	5 264 Ft
○ B	világosszürke/természetes fehér, méret 110 x 172 cm, vastagság 1,6 mm, súly 560 gsm, felületi súly 190 gsm	KL021105		4 613 Ft	5 858 Ft

Figure 5.1: Shows the cost of an E-flute corrugated sheet. [50]

5.1.1. Package of 7 pill boxes without stand

Total width of package =303mm

Total Height of package= 374.5mm

By cutting the package from the sheet in the most efficient way 12 packages can be produced using the smaller sheet (option (A)) *(refer to figure 5.1)* and 12 can be produced from the bigger sheet (option (B)).

Thus:

$$\frac{5264ft}{12} = 438.7ft\ per\ 1\ package$$

$$\frac{5858ft}{12} = 488.17ft\ per\ 1\ package$$

Therefore, using the sheet from option 1 not only reduces cost but it also reduces waste.

[50] Websolutions. (n.d.). Hullámkartonok MW 1,6mm | www.ceiba.hu. Ceiba s.r.o. Retrieved December 5, 2021, from https://www.ceiba.hu/hullamkartonok_mw_1_6mm

5.1.2. Partition

Total width of package =82 mm

Total Height of package= 629.5

By cutting the package from the sheet in the most efficient way 24 partitions can be produced using the smaller sheet (option (A)) and 26 can be produced from the bigger sheet (Option (B)).

Thus:

$$\frac{5264ft}{24} = 219.33ft\ per\ 1$$

$$\frac{5858ft}{26} = 225.37ft\ per\ 1$$

Therefore, using the sheet from option (A) less partitions can be produced however at a cheaper price per partition meaning lower overall cost.

5.1.3. Package of 7 pill boxes with stand

Total width of package = 447.75mm

Total Height of package= 241.96mm

By cutting the package from the sheet in the most efficient way 14 packages can be produced using the smaller sheet (option (A)) and 14 can be produced from the bigger sheet (Option (B)).

Thus:

$$\frac{5264ft}{14} = 376ft\ per\ 1$$

$$\frac{5858t}{14} = 418.4ft\ per\ 1$$

Therefore, using the sheet from option (A) can produce the same amount of packages with lower price and lower waste.

5.1.4. Single box Package

Total width of package = 205mm

Total Height of package= 153.5mm

By cutting the package from the sheet in the most efficient way only 48 packages can be produced using the smaller sheet (option (A)) and 56 can be produced from the bigger sheet (Option (B)).

Thus:

$$\frac{5264ft}{48} = 109.67ft\ per\ 1$$

$$\frac{5858ft}{56} = 104.67ft\ per\ 1$$

Unlike the other packages, for the single box package option (B) would cost less than using option (A) and would also yield 8 more packages from one sheet.

6. CONCLUSION

In conclusion the pill box design would be an important product in every household whose users have to adhere to a strict medication regime. It is a simple yet effective solution accompanied with the app. The presence of 2 version of the pill boxes provides more choices for people depending on their preferences hence increasing the target audience. This also applies to the different versions of packaging where a person can choose how many pill boxes to purchase depending on their needs.

For further development a focus group consisting of caregivers, elderly users with chronic illnesses and occasional pill takers could be arranged in order to test the product and identify any weak points to be redesigned or modified. In the long run the idea could become bigger to include a whole system that can be used in care homes to reduce any errors towards the patients. The pill box and app could be used to track the patients' medication effortlessly, or might be used to share information of medication history between patient and doctor.

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