Male Barrier Model

Nick Balge, Whitney Johnson, Terra Gahlman, John Cheadle

Advisor: Prof. Pamela Kreeger

Client: Mrs. Marge Sutinen

03/09/2009

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1. Background:

For the past three decades, HIV/AIDS has been a world-wide epidemic. Lack of knowledge about the disease is a major concern, and ignorance toward protection is a problem that our client has fought against since the late 1980's. She currently teaches a class at UW-Madison titled "Contemporary Issues on HIV/AIDS", and it is for this class that she is looking for a demonstration tool that could be used to educate students about the strength of commercial condoms. This idea originally stemmed from a presentation that Mrs. Sutinen had performed early in her career of teaching students about HIV/AIDS. The presentation consisted of funneling lead pellets into a condom supported by a ring clamp. The venture was very rugged, as she had simply used discarded resources that were available from a friend's lab. However, it was sufficient to show students that the popular rumors surrounding condoms (they broke easily, there were holes or worms in them, etc) were false. One of her colleagues, Jenny Page, a biology teacher in South Africa, witnessed Mrs. Sutinen's demonstration and took the idea back with her to South Africa (also using resources from her lab). There, the presentation had even more of an impact, as the stigma and myths surrounding condoms and HIV are extremely exaggerated. Mrs. Sutinen plans on sharing it with Mrs. Page, who she is still close with, to spread the message of protection to South African students at risk for HIV, as well as re-introducing her students to the demonstration. Even though the United States population is much more aware and informed about the AIDS virus and condoms those in South Africa, people are still uncomfortable talking about protection and college students are at risk of buying into the rumors surrounding condoms. Mrs. Sutinen believes that the demonstration tool would be an excellent way for her students to debunk myths about condom strength and encourage discussion about condoms and protection amongst their peers.

2. Project Assignment:

For our design project, we will be formalizing the initial idea and building a portable demonstration tool that would allow a suspended condom to be loaded with a dense material until it broke, with the amount of weight being held by the condom visualized by a scale. While the physical strength of condoms (i.e. How they hold up against 10lbs of force) is not the main concern when educating people about protection, the device is mainly for a shock factor and will be useful in de-stigmatizing condoms and open up conversation about protection and sexually transmitted infections. Mrs. Sutinen is planning for the students of her class to be the primary users of the design project. The students would be demonstrating to their peers, and this would not only make students familiar with barriers, but would spread the message of protection to the younger generation of students. Mrs. Sutinen also plans on introducing the design to her colleague in Africa, which will help to confront the myths and stigma about condoms in an area where HIV/AIDS is extremely prevalent and discussion about barriers is usually misguided hearsay.

3. Client Specifications:

Upon meeting with our client, we were given a few general guidelines to follow while designing our device. These aspects were absolutely necessary to include, even though we were more or less given creative control in the direction we wanted to take with our model. The following guidelines can be summed up below:

- Presentable – Mrs. Sutinen teaches a class on HIV/AIDS, and needs this tool for her students to better teach the effectiveness of male barriers. This model will be the focal point of these lectures, and for that purpose, needs to be very presentable. This includes being viewable (especially from the back of the classroom) and being aesthetically pleasing.
- User-Friendly – The students in Mrs. Sutinen's class will be the ones using this device the most – their task is to teach a presentation to the rest of the class about the strength of male barriers using our device. Some of these students may or may not have much technical experience and skill; therefore, we need this design to be as intuitive and simple as possible. We also have to consider that this device may be used in other places of the world, like Africa, to demonstrate strength of barriers. This further prompts us to make a device that easy to teach and easy to use.
- Portable – This was stressed by our client to be a very important feature. Making this device portable allows for its use anywhere, which we want to eventually include outside of the U.S. For our purposes right now, a feasible reason to make this portable is to allow for easy transfer to different classrooms on campus or even other school districts. This issue of portability will be discussed later in both the design constraints and design matrices.
- Inexpensive – Though not as important of an issue as the preceding three, cost is definitely something we have to be wary of during this semester. The original budget was proposed at $100.00, but this could be increased due to the necessary purchase of lead pellets. We have already spent about 2/3 of our budget on a scale and telescoping poles – we still need to buy more mechanical parts, but all of our major purchases (save the pellets) have been taken care of. The cost reflects the desire to have a quality (but not extremely technical or

detailed) product, that could be easily reproduced if need be, a notion which summarizes the final guideline.

- Reproducible – Once the final design is used in the classroom and our client feels the need for more of these to be created and used, we want to make sure that the construction of extra models will be quickly and efficiently done.

Armed with these preconditions, we decided to do some testing before we began to draw and brainstorm our ideas. This testing included the stretching of barriers by hand and putting different types of weights in the barriers. After two weeks of brainstorming and drawing designs capped off with an additional, very informative meeting with Mrs. Sutinen, we were able to define our design constraints with confidence.

4. Design Constraints:

Constraints apply specifically to three different areas of our design: the scale, the clamp, and the structure. There is some overlap between the three areas, but most constraints can be confined to just one.

- Structure: The structure has the most functionality of the three designs. First, it must be able to support the weight of the scale, clamp, barrier, and weights. We estimate this to be around 10 lbs, although we have not received pellets yet and thus can not say with exact certainty how much this will all weigh. Since this demonstration will be used repeatedly, the structure has to be sturdy enough to withstand this. In addition, the whole structure (and all parts associated) must be able to disassemble and fit in a suitcase to be transported. Similarly, we must have the structure be at least 4 ft. in length to account for the condom stretch. In short, we must have a main structural element that can reach a great height while still having the capability to compact and be disassembled. The assembly of the model must be intuitive, and ideally will not take much time. Finally, the structure must be aesthetically pleasing, as it will be used as the focal point in a classroom demonstration.

- Scale: The scale is more or less the most interactive part of the entire design. It is the part that students will be most able to relate to, and conveys the general purpose of the model. For that purpose, it is most important that this be readable (even from the back of a classroom), and that it places an emphasis on presentation. It is not as important for the scale to be incredibly accurate, as the client is looking more for a “wow factor” than an exact, quantitative measurement. Plenty of expensive devices exist to test condoms to a high accuracy, although none exist (that we’ve found) that place an emphasis on demonstration for learning purposes.

- Clamp: The clamp will be the most intricate, and by far the most challenging aspect of our design to manufacture. It follows that this element will be the hardest to use, and unfortunately will be the part that is most interacted with by the student teachers. Therefore, it is imperative that we make this clamp as intuitive and simple to use. Loading the lead pellets must be straightforward, meaning that it should be easy and innate to put pellets in once the condom is attached. Likewise it should be simple to clamp the barrier in place, without tearing the material and causing it to rip prematurely. Finally, testing will need to take place to assess whether the clamp can hold the weight of the barrier and weights combined, which will be about 5-10 lbs depending on how much the barrier can hold.

5. Ergonomics and Human Factors:

The topics of usability and accessibility do apply to many aspects of our design. The fact that our device could be used by nearly anyone (not just someone with specific training or in a specific profession) as a teaching tool encourages us to make it as user friendly and accessible as possible. Each of the seven principles of universal design applies to our product, some more so than others. An important focus for us is equitable use – nearly every adult should be able to use our product, as there is low physical effort required (lifting of ~10 lbs or less), and design is symmetrical in nature and easily accessible from all angles, eliminating the preference for handedness. One foreseeable problem is the height of the device. Since the barrier may stretch up to four feet, our stand includes adjustable, telescoping poles that reach this height. If placed on a table for easy viewing, it may be difficult for a very short person to access. If need be, however, the device could be placed on the floor, and this eliminates the height issue. Secondly, we want our design to be intuitive and simple to use. In our design matrices this aspect has high importance, and we will incorporate this accordingly. Our design is intended to be portable, and will therefore require assembly. In addition, the clamping mechanism may not initially be intuitive. Our solution for this is to include some sort of written manual for assembly and utilization of the device; we are also providing first-hand instruction to the clients, who will in turn use this device to teach classes about male barriers and the HIV/AIDS epidemic. Our hope is that assembly will take no more than a few minutes, and that we will be able to completely convey how to use this device to teachers in a similar amount of time. Finally, paramount to all other issues is that of client safety. In the early stages, our group was worried about what would happen when the barrier broke. As we found out from previous trials, the pellets more or less stay localized and do not scatter; however, we will be including a container into our design that will fit snugly between the two poles to catch the pellets as they drop. We will also suggest that the demonstrators wear gloves (if we decide on lead pellets) and protective eyewear, just as a precaution. Following these guidelines, our group will succeed in making a safe device that is intuitive, accessible, and aesthetically pleasing.

6. Design Choices:

Since we have too many constraints to contain in just one design matrix, these three aspects instead comprise our three design matrices. The following material contains our three design matrices for the scale, clamp, and structure; it includes explanations of our options for each, as well as our final choice and reasons for this.

a. Scale Choice:

As can be seen in the design matrix below, our choices for scale include a digital display, an analog display, or a force transducer module. Our categories were weighted according to their importance: readability was our primary concern for reasons outlined earlier in the paper. Cost and portability were nearly equally important; scales can potentially be very expensive, and this weighting reflects that. Also important, though somewhat of a secondary factor, is the aesthetics of the device. In short, we wanted a scale that looked presentable. Accuracy was not a huge determining factor in our matrix, as it is not the main focus of this device. We surmised that any scale we would use would be adequate in terms of accuracy.

- Digital Display: A digital display was actually one of our first ideas when we were brainstorming ideas. Digital displays of the scope that we needed are commonly used in fishing to weigh the fish. They are compact,

Figure 1: Digital Scale

and some models are not terribly expensive. Unfortunately, the display is very small, and only someone very close to it could be able to read it. We had early thoughts to possibly try and make this display larger, but figured it would be out of the range of our abilities.

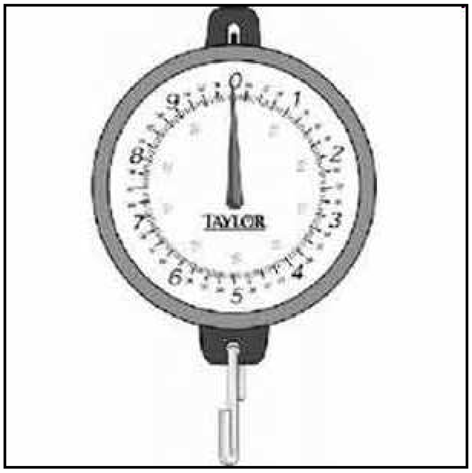

Figure 2: Analog Scale

- Analog Display: The analog display shines in the areas of cost and readability. Though some analog displays can run incredibly high, there are some models that are relatively inexpensive and perfect for our purposes. In addition, the dial and numbers of an analog scale are generally large enough to be seen from far away. The analog display scores lowest in the accuracy section, but that is not a huge problem. It is also less portable than we would like due to its size, but in general the advantages outweigh the disadvantages.

- Force Transducer: The force transducer would be by far the best choice for this device, as it has a large digital display, is incredibly accurate, and looks very presentable. Unfortunately, the price of a force transducer far surpasses the confines of our budget ($300.00 and up). In general, such a sophisticated piece of machinery would not make sense with the scope and purpose of our device.

Figure 3: Force Transducer

Decision Matrix – Scale Choice:

Scale	**Digital display**	**Analog Display**	**Force Transducer**
Cost (12)	7	**11**	1
Readability (15)	8	**11**	13
Aesthetics (8)	4	**6**	7
Accuracy (4)	3	**2**	4
Portability (11)	10	**9**	6
Total	32	**39**	31

Figure 4: Scale Decision Matrix

Final Scale Design: We decided to opt for the analog display, mainly due to the quality and size of its display and the relatively low cost. While some other factors were less than desirable, our group believes that the positives generally outweighed the negatives.

b. Clamp Design:

During the clamp design process, our most important objective was to ensure that the structure could securely hold a condom without creating points of concentrated strain that would lead to unpredictable ripping. Another important consideration for the clamp design involves the ease of set-up. Quick and simple assembly is required in order to cater to efficient classroom use and also to inexperienced users. Also, the clamp must be sturdy enough to undergo repeated demonstrations that involve it supported up to ten pounds.

- Design 1: Bicircular Clamp

Our first clamp design consists of two circular shaped pieces of metal connected together by small rod that can be adjusted with a screw – type mechanism. To use this clamp, the user would

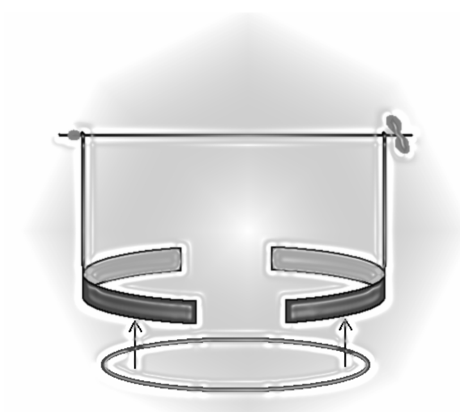

Figure 5: Bicircular Clamp Illustration

insert a metal ring into the top of the barrier, align the ring with the clamp, and then tighten the structure holding the condom in between the metal pieces. Ideally, we would coat the metal pieces with rubber or a similar material in order to create a better seal to the condom and prevent tearing.

- Pros

➢ Tight seal around condom

➢ Decreased concentrated strain in condom

➢ Only one part requires adjusting/tightening while attaching condom

- Cons

➢ May be difficult to line up metal ring with the circular pieces of clamp

➢ Several pieces to manufacture

- <u>Design 2: Tripoint Clamp</u>

Our second clamp design consists of a solid, circular structure that carries three small "pinch" clamps at the bottom end. These clamps would be attached directly to the condom, creating three points of contact. A hole would be drilled down the middle of the structure in order to allow for the loading of lead pellets.

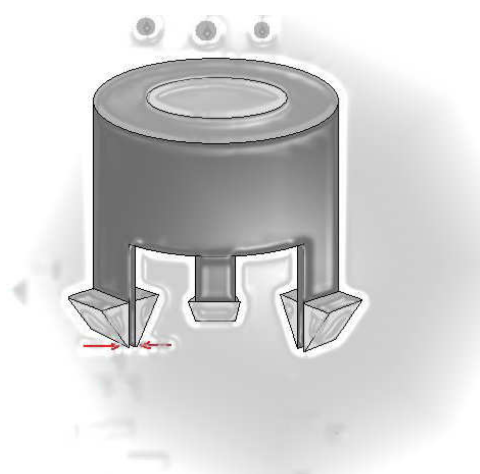

Figure 6: Tripoint Clamp Illustration

- Pros

➢ Easy to attach condom

➢ Sturdy Structure

- Cons

➢ Difficult to manufacture

➢ Produce concentrated strain on condom through points of contact

➢ High cost

- <u>Design 3: Monocircular Clamp</u>

Our final clamp design consists of a single ring, made out of a slightly more pliable metal, and an adjustable screw mechanism at one point to complete the ring. Similar to the first design, the user would insert a circular, sturdy metal piece into the top portion of the condom, slip the clamp over top of the ring, and tighten the screw with the condom between the two ring structures. Again, the metal pieces would ideally be covered in a rubber – like material.

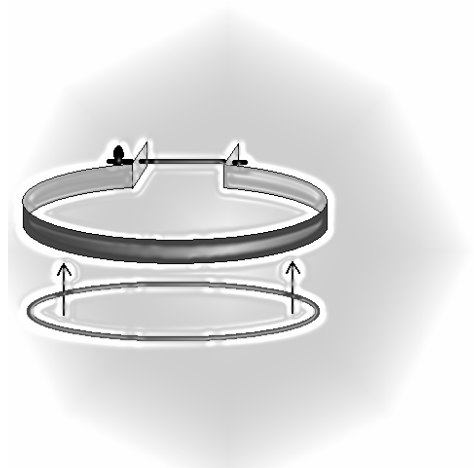

Figure 7: Monocircular Clamp Illustration

- Pros
  - Decreases strain on condom
  - Simple design
  - Easy to assemble
- Cons
  - Requires use to line up system of rings

Decision Matrix – Clamp Design:

Clamp	Bicircular	Tripoint	Monocircular
Cost (4)	3	1	**4**
Loadability (10)	9	5	**8**
Ease of Setup (12)	7	10	**8**
Manufacturability (12)	8	6	**10**
Material Compatibility (12)	10	4	**9**
Total	37	26	**39**

Figure 8: Clamp Decision Matrix

Final Clamp Design

Five criterions were included in our decision matrix: cost, loadability, ease of setup, manufacturability, and material compatibility. Material compatibility refers to the potential of the clamp to reduce stress on the condom. Due to its high scores in the three strongly weighted categories, the monocircular clamp design will be integrated into our final product.

c. Structure Designs

The final component of our design to be individually analyzed is the basic structure of the apparatus. As the demonstration will likely take place in front of classrooms, the structure needs to be tall enough to be visible to all students. Also, it must be large enough to accommodate a condom that is fully loaded with lead pellets. Another important consideration in this design it's stability: it must be able to accommodate approximately ten pounds of weight that will be sitting at different points at different times during the loading process, creating different centers of gravity.

- <u>Design 1</u>

The first design consists of a solid base and a telescoping rod. Because the rod can be compacted, it allows our structure to be more portable. The scale would be fitted to attach to the upper end of the rod.

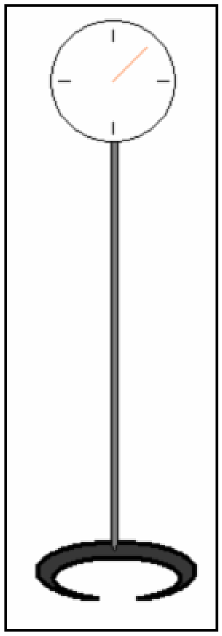

Figure 9: Single Pole Structure

- Pros
  - Portable
  - Easy to manufacture
- Cons
  - Not overly stable
  - Less area to attach additional features

- Design 2

The second design is similar to the first, but consists of two telescoping rods instead of one.

- Pros

➢ Portable

➢ Easy to manufacture

➢ Stable from side to side

- Cons

➢ Could be more stable with front to back motion

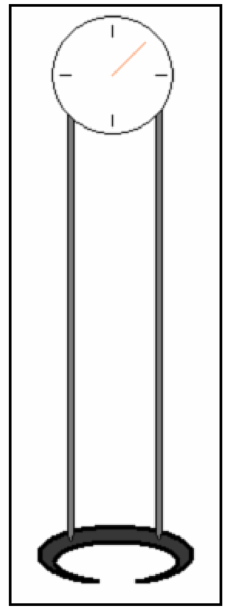

Figure 10: Two-Pole Structure

- Design 3

The third design under consideration includes a Plexiglas box on which the clamp and scale would be stationed. A five sided box would be manufactured with an open top, which would be fitted with a specialized piece of material designed to house the clamp and support the scale.

- Pros

➢ Aesthetically pleasing

➢ Sturdy

- Cons

➢ Expensive

➢ Not portable

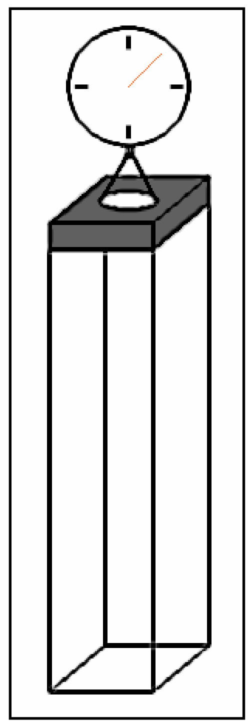

Figure 11: Plexiglas Box Structure

Decision Matrix: Structure Design

Structure	1 Pole	2 Poles	Plexiglas Box
Cost (10)	10	**8**	4
Portability (10)	10	**10**	3
Aesthetics (10)	6	**7**	10
Stability (10)	3	**7**	9
Manufacturability (10)	9	**9**	4
Total	38	**41**	30

Figure 12: Structure Decision Matrix

Final Structure Design

All equally weighted, the structure designs were rated in the decision matrix based on cost, portability, aesthetics, stability, and manufacturability. The 2-pole structure will be incorporated into our final product based on it's portability, low cost, and stability.

7. Future Work

a. Building

Base: Before building the base, dimensions will be specified for its approximate length, width, and height. These will serve only as guidelines because the actual size of the base will not need to be exact. The base will ideally be as small as possible while maintaining stability under a 10 lb load.

Two holes will need to be drilled into the base for the poles to be placed into during assembly. The diameters and locations of these holes will need to be much more precise than those of the base as a whole. The diameters will need to match the diameter of the poles. The holes will be made symmetrically front to back and side to side to maximize the balance of the base. Spacing between the holes will match the spacing between the pole attachments on the back of the scale.

Scale: The scale will need to be mounted onto the tops of the two poles that are rising up from the base. Clamps or brackets will be attached to the back of the scale. During assembly, the poles will slide into these clamps, and the clamps will tighten around them. The clamps will need to be permanently attached to the scale. This will be done by drilling holes in the back of the scale so that the clamps could be secured with screws.

At the bottom of the scale, there is already an attachment for items to be hooked on and weighed, so this part of the scale will not need to be modified.

Clamp: The clamp will be made from a strong metal that is not easily deformed with repeated loadings. Hopefully, an item will be able to be purchased that is similar to the monocircular clamp that was selected for the final design. Its diameter should be similar to that of a condom and will need to match closely the diameter of the ring that will be inserted inside the condom. Any clamp that is purchased may need to be modified slightly before use, and in the most extreme case, a the clamp part may need to be fabricated from scratch.

A piece of metal will need to be attached to the clamp so that it can be hooked onto the scale. This will consist of two metal bars that will be welded to the sides outside of the clamp at opposite ends. The bars would then meet and be above the clamp. They will be joined and either welded to a hook or simply welded together so that they could easily be placed on a separate hook. The length of the bars should not be too long, which will save space both during storage and while assembled, but the length should also not be too short, so that there is room for lead pellet delivery.

Pellet Trap: A container will need to be placed below the clamp so that the lead pellets will be caught when the condom fails. This trap could potentially be any container that is large enough to catch all of the pellets and small enough to fit between the poles of the structure. Ideally, there will be time to design such a trap that specifically fits our device. It will likely have two notches or holes so that it can be a relatively large container and still fit snugly between the two poles.

Pellet Delivery: If time allows, a funnel will be attached to the back of the scale with tubing running down toward the clamp. In this way, pellets will be delivered in a way that is exciting and engaging for the students. If there is not time to implement pellet delivery, the students will have to place pellets through the clamp and into the condom by hand.

Ruler: If time allows, a ruler will be included so that students can measure how far the condom is stretching in addition to the weight that is being held. This would likely be attached to one of the poles with Velcro for easy assembly and removal.

Painting: If time allows, the structure will be painted so that is has a more pleasing appearance. A grey shade of paint would probably be used to promote a professional appearance.

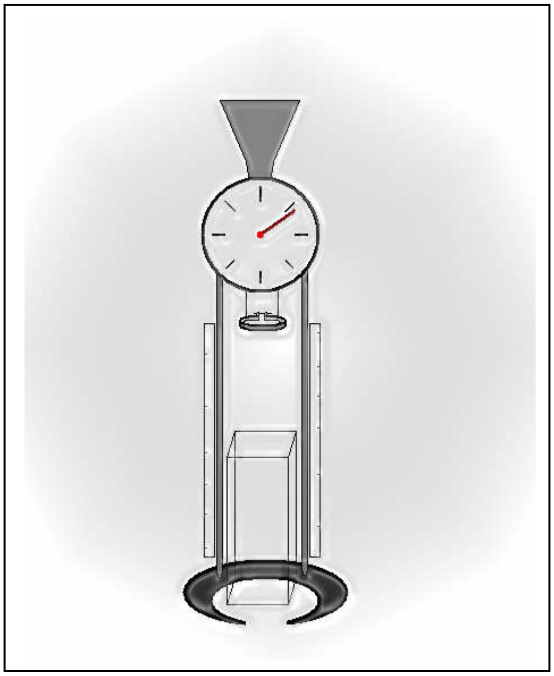

Figure 13: Final Design Illustration

b. Testing

Failure Test: The ability of the device to perform repeatable experiments will be tested. Condoms should be able to sustain as large a weight as they would if they were being held in ones hand. Ideally, this weight should be consistent for a certain make of condom and vary slightly between different makes to potentially widely between different materials.

The clamp will be observed closely to ensure that it is not contributing greatly to the failure of the condom. Failure around the clamp may be somewhat inevitable because condoms typically rip in this area when stretched, but the clamp should not be the primary cause.

Stability Test: The structure must be tested to ensure that it will not wobble in either direction during experiments. If the device were to fall over, it could break or injure students. It must stand upright with adequate stability under 10 lbs of loading.

The structure must also be securely held together to, again, avoid injury to students or damage to itself. Repeated tests will be run to see if certain parts of the structure become loose over time. This will simulate the repeated loadings that the structure will undergo during classroom use.

Pellet Containment Test: The behavior of the lead pellets during failure must be tested to confirm that they will fall straight down. Pellets that escape for any reason would be wasteful, and they could also be potentially harmful if they escape with a trajectory. This information needs to be known ahead of time so that a guard could be implemented if necessary.

c. Classroom Presentation

Safety: Based on the results of testing, a safety protocol will be implemented for classroom use of the device. This will be developed with help from some of the client's students at the end of the semester. It is likely that students will be required to wear safety glasses when using the device.

Experimental: Again with the help of the client's students, a procedure will be developed for experiments to run experiments with the device. It is anticipated that this responsibility will taken mostly by the client's students, after they are instructed on how to use the device.

8. Potential Problems

With the requirement of lead pellet purchasing and shipment, the budget of $100 that was initially proposed for the project may be slightly exceeded. This additional cost will be provided by the client but should still be kept as small as possible. The scale has been received, and its back is made out of plastic rather than metal backing we expected. This could potentially pose a problem in structural support, but the pole clamps should still be able to be attached with screws rather than welding.

9. Conclusion

The three main aspects of the male barrier model design have been decided upon. An analog scale was chosen as the weighing device because of its large display at a relatively low price. The monocircular design was chosen for the clamp because of its simplicity and equal distribution of force around the condom. The two pole design was chosen as the structural support because it provides sufficient strength and is feasible given both cost and time constraints. This design will meet the client's requirements and will provide a useful classroom tool for condom education and the fight against HIV/AIDS.

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Appendix A: Product Design Specifications

Team Members:

Nick Balge – Team Leader

Terra Gahlman – Communicator

John Cheadle – BWIG

Whitney Johnson – BSAC

Function: To demonstrate to classrooms with students of various ages the strength of latex and polyurethane male barriers. This will be accomplished by inserting lead pellets or a different dense material into the barrier and displaying the resulting weight it can hold.

Client requirements:

- portable
- classroom and user friendly
- inexpensive
- reproducible

Design requirements:

1. Physical and Operational Characteristics

a. *Performance requirements*:

- Able to withstand repeated demonstrations (approx. weight ~10 lbs.)
- Must clearly and accurately display weight
- Stable structure
- Able to secure latex and polyurethane in place

b. *Safety*:

- Must prevent pellets from scattering upon barrier failure
- Must prevent latex/polyurethane from scattering
- Barrier clamp must not be dangerous

c. *Accuracy and Reliability*:

- Should provide repeatable results
- Accuracy to the nearest .1 lb would be desirable

d. *Life in Service*:

Must withstand repeated use
Average number of demonstrations during which the tool will be used in its lifetime has yet to be determined.
Should be designed to last a number of years before becoming dysfunctional

e. *Shelf Life:*

Some components may require a dry space for storage
Scale may require the tool to be used and stored at room temperature away from heaters or air conditioners.
Scale may require batteries of standard shelf life

f. *Operating Environment*:

Classroom environment will prevent the device from operating under adverse conditions
Students may handle device, should be durable
Must be tolerant of dust if stored

g. *Ergonomics*:

Height and shape must allow for easy placement of lead pellets into the barrier.

h. *Size*:

Height must be approximately 4.5 to 5 feet.
Floor space will be minimal
Will likely be able to be disassembled
Must remain small enough to be portable

i. *Weight*:

Light and easily portable
No quantitative data is yet available
Must be able to withstand 10+ pounds of strain easily

j. *Materials*:

Must be able to be handled by students (nothing fragile or harmful in any way)

k. *Aesthetics, Appearance, and Finish*:

Sleek and professional appearance
Should focus attention to condom and weight reading
Must have a clear casing, if any, to ensure condom visibility

2. Production Characteristics

a. *Quantity*:

One unit is currently required with possible future reproducibility being a primary design concern

b. *Target Product Cost*:

Should be relatively inexpensive
Around $100 total

3. Miscellaneous

a. *Standards and Specifications*:

none

b. *Customer*:

Small
Inexpensive
Liked the idea of lead pellet use

c. *Patient-related concerns*:

Device needs in include additional male barriers/storage area for additional demonstrations
After barrier breaks, students should be shielded from possible scattered pellets
Large enough display to read from a reasonable distance

d. *Competition*:

There are commercial products that test the strength and effectiveness of male barriers, but we are not aware of any devices specifically for classroom use.