The Safety Net

“Now parents and children can both rest easy”

Nancy Cowles, of Kids in Danger (KID)
Team 2, Section 01
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Northwestern University
June 11th, 2013
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Executive Summary

PROBLEM

Even though cribs are held up to tough standards recently set by the CPSC, they are still dangerous. KID (Kids in Danger) wanted a solution to these dangers; they wanted a safer environment for children to sleep in. An inexpensive, easy addition to cribs is necessary to improve their safety and prevent children from being hurt or dying in their crib. This device needs to stop children from trapping their limbs between the slats of the crib, prevent children from falling out of the crib, and provide adequate air flow to prevent suffocation. The safety concerns were kept front and center during the design process to create the safest crib possible.

What makes the Safety Net such a universal design is its viability as an after-market product. The Safety Net can be easily installed into any crib approved by the new CPSC standards, whether it be sold with a crib or bought after the fact. The Safety Net increases the safety of any crib, and it is easy to install, maintain, and reuse. Furthermore, it is inexpensive to manufacture, which means high profit margins regardless of the final price.

DESIGN FEATURES

A. MESH SIDES ARE SAFER THAN SLATS
   i. Has holes to allow breathability but the holes aren't big enough for fingers
   ii. Acts as a barrier between the child and the slat wall

B. INSERTABLE RODS MAKE SET-UP EASY
   i. Easily installed by the parents
   ii. Easily taken out to wash the mesh sides

C. CURVED COVERS ARE HARD TO CLIMB ON
   i. Harder for the growing child to grasp and climb up on
   ii. Covers the pieces of the device that have the rods

Figure 1: Front View of Safety Net
1. Introduction

Cribs are full of hidden hazards to babies. The slatted walls of the crib are rife with problems. First, if the slats are too far apart from each other, children can get any part of their bodies trapped, from their hands to their head. The entrapments can lead to strangulation, suffocation, twisted limbs, and broken bones. The second major problem is that as babies grow older, they also grow taller and develop better control of their fine motor skills. This enables them to climb out of the crib and fall to the ground, resulting in serious injuries.

Another important note with current cribs is, although the safety regulations and standards for crib changed in 2012, many parents will opt to use either a second-hand or hand-me-down crib in order to save money. While the structure of these cribs might be sound, there are many features deemed unsafe by the United States Consumer Product Safety Commission, such as drop-down sides, wide gaps between slats, or difficult assembly. Furthermore, many of the safest cribs on the market today are not aesthetically pleasing, so parents are less likely to buy them.

The Safety Net solves many of these problems that befall even the new CPSC standards. The Safety Net is designed to be:

i. Safe
ii. Durable
iii. Easy to set up and clean
iv. Inexpensive
v. Able to fit over the frame of existing cribs
vi. Reusable

The Safety Net solves many of the problems that normally plague cribs currently found on the market. Our Safety Net is made to be safe, durable, inexpensive, and universal. In the following sections of this report, we will explain in depth the problems and concerns with current cribs; what our design process was in creating the best solution to those problems; the final product and what it specifically entails; and, finally, what our recommendations would be in regards to manufacturing The Safety Net on a larger scale. Any additional research or information can be found in the Appendices B, C, D, and G.
2. Users and Requirements

2.1. The Problems with Current Cribs

The current cribs on the market have many problems that have not been addressed well according to our client Nancy Cowles who represents the organization KID, Kids in Danger. There are approximately 50 deaths and eight thousand injuries attributed to cribs per year. The bars on the crib represent the biggest problem because infants get their limbs stuck between the bars, clothing can get stuck between the bars, and in the worst cases, their heads can get stuck between the bars, leading to severe trauma or death. A safe crib should not have a drop down side because it often breaks and cannot withstand years of parents and children leaning on or pushing against it. The slats should be no more than 2.38 inches apart from each other.

2.2. Users and Other Stakeholders

The primary users of The Safety Net are the infants and young children who will sleep in this crib. Although children sometimes continue to use the crib past age of three, the recommended age for children to sleep in cribs is from ages 0 to 3. The secondary users are the parents who are responsible for buying, setting up, maintaining, and storing the crib. They have a stake in its safety as well as its aesthetic appeal.

2.3. The Critical Design Requirements for The Safety Net (see Appendix B)

2.3.1. Safety Standards

Certain design characteristics are more important than others, and the safety of the design was determined to be the top priority through thorough reasoning. The Consumer Product Safety Commission safety standards must be met by the design, specifically referring to the "component entrapment", or bars supporting the crib. There are approximately 8 thousand injuries a year from cribs, in large part because of the gaps between the bars. A good crib should have minimal risk for harm by its bars.

2.3.2. Durability

Another highly prioritized aspect of the design is that it will last a long time. Many times people do not want to purchase a new model, so this design must be durable enough to withstand constant use and roughness from both the children and parents. Furthermore, it should be easy to maintain and possibly washing machine friendly, so that it can stay in good condition for a long time and clean.
2.3.3. Social Interaction

The design should encourage social interaction between the child and those outside the crib. The child should have easy viewing access to the outside world that the bars currently allow. The parents should feel the same way about their access to the child. They should be able to see the child easily as well. Furthermore, they should be able to physically interact with the child easily. The design must provide the same accessibility that a drop-down side provides without being as dangerous for the child.

2.3.4. Ease of Assembly

The assembly of the design should be simple, straightforward, and intuitive. There should be no need for a specialist to help set up the design. In addition, the design should be easy to dissemble and store in an unobtrusive way.

2.3.5. Aesthetics

The design should lastly be aesthetically pleasing to the users. If the design is good looking, parents are more likely to buy, use, and keep it for a later date. Additionally, in the client interview with Nancy, we learned that a professor in the Chicago area recently tried to manufacture an extremely safe crib, but because it was not aesthetically pleasing, manufacturing companies did not think it would profitable to make on a large scale.
3. Design Concept and Rationale

3.1. Design Overview

The Safety Net is a mesh net which is placed along the inside of the crib while attached to the frame of the crib via a series of rods and clips which sit along the slats of the crib. The clips themselves are covered by a wide, curved shield which sits along the entire length of each crib wall. The netting prevents the child from entrapping their limbs between the slats while simultaneously providing ventilation in case the child presses their face against the mesh walls. The rounded shield along the top of the slat walls covers the clips which keep the net up while making the top of the slats harder for children to get a firm grasp on, making it more difficult for children to climb out of the crib. For the list of materials, see Appendix I. For building instructions, see Appendix H.

3.2. Design Features

The Safety Net is a box-shaped mesh net with dimensions of 52” x 28” x 28”, as designed to accompany standard size mattresses. The bottom of the net is a canvas support which sits underneath the mattress and remains inaccessible to the child. Along the edges where two walls meet is another strip of approximately 3” wide canvas where the mesh is sewn into. Along the top of each visible face wall is a folded piece of canvas which forms a tunnel for a support rod to be inserted. The support rods keep The Safety Net fully stretched and uniform in shape.

Figure 2: Outside view of Safety Net
The clips are rectangular, “U”-shaped pieces with outer dimensions of 3” x 3” x 2”. Each clip along the longer crib walls have a 0.5” diameter hole drilled 2” deep in one of the corners of the square face. The holes are wide enough to accompany 0.25” wide support rods wrapped in canvas while preventing the rods from slipping in between the slits. If the Safety Net needs to be cleaned, it can be easily removed from the clips by sliding the support rods out of the clips and removing the net from between the clip slits.

Figure 3: Clip and Rail system of Safety Net

The curved component is made to cover the clips and support rods while widening the area on top of the walls of the crib. With a greater amount of surface area, the top of the crib walls becomes more difficult for children to grasp, which prevents children from climbing and falling out of the crib.

Figure 4: Inside view of Safety Net  
Figure 5: Front view of Safety Net
4. Future Recommendations

The Safety Net is a great design to manufacture on a larger scale for several important reasons. It is inexpensive to manufacture, which means the company can produce a huge profit margin while the consumer can still purchase The Safety Net at a lower price than competing nursery products. Furthermore, since The Safety Net is an after-market product, all parents can buy it without needing to buy a new crib. The Safety Net makes all cribs safer and is a welcome purchase for many parents. They will see The Safety Net as a long-term, worthwhile investment.

There are several recommendations we can make before taking The Safety Net to market. First, a less elastic mesh will prevent children’s limbs from extending any further outside of the crib.

In future builds of the crib, the clip and rail pieces can be combined to form one full-length piece which sits along the entire length of the rail. This piece can be made from an extrusion mold for easy manufacturing and will reduce the number of parts needed for assembly. The extrusion mold can also be made to fit more securely along the top of the crib.

Finally, we recommend manufacturing the net in different colors and patterns. The mesh fabric can be painted in a variety of colors, which adds aesthetic appeal to The Safety Net. This can also be done to the blocks on top, making each net more personal to the consumer. A variety of options will also increase the consumer market.

Figure 6: Sample render of extrusion-based rail
5. Conclusion

The design of The Safety Net is a unique approach to keeping children safe in cribs. The Safety Net incorporates simple design ideas to create a safer crib environment that solves some of the problems that plague traditional cribs. One of the biggest features of The Safety Net is that it is not a new crib, but instead a device that sits on top of existing cribs. To change the idea that the walls of a crib have to consist only of wooden slats, the decision was made to introduce mesh sides. These sides prevent the child from inserting their limbs or head between two slats and hurting themselves. Another benefit of the mesh is that it is very breathable, so there is no chance of the baby suffocating against the walls of the crib. The mesh sides are implemented through an easily assembled set of formed pieces that sit on top of the crib walls. Covering these pieces, to prevent tampering, are covers that span the length of the crib. These pieces have sized holes to allow rods, with mesh sewed in a loop around them, to be easily inserted. Easy installation of the rods also means that they can be easily taken out, the mesh slide off and cleaned.

The Safety Net is a combination of multiple simple but helpful design features to create a crib add-on that can radically change the safety records of cribs. Broken limbs and suffocation are no longer worries with The Safety Net. Assembling The Safety Net is simple and intuitive. Both of these accomplishments were goals we outlined in our Mission Statement. Another advantage to The Safety Net is that it isn’t an entire crib. It does not have to compete with other cribs on the market, it can be bought and attached to most cribs. This universality will ensure it spreads to the most people and protects the more children. This is the ultimate goal of KID, and The Safety Net without a doubt delivers on all fronts.
Appendix A: Project Definition

**Project Name:** Development a Better Crib

**Client:** Nancy Cowles from the organization KID: Kids In Danger

**Team Members:** Annabel Buckfire, Hannah Jones, Jason Vignolo, Chris Mischenko

**Date:** April 14, 2013

**Mission Statement:**
We want to build an attachment to existing cribs found on the market today so that an infant or young child cannot suffer from possible suffocation, strangulation, falls or entrapment of limbs. This attachment will alleviate these problems by solving the problems that slats create. It will meet the tough standards set by the CPSC, the Consumer Product Safety Commission. The attachment will be durable and easy to move and assemble by parents.

**Project Deliverables:**
At the end of the project, a prototype new crib attachment will be given to the client as well as sketches and a clear explanation of the design process. There will also be a PowerPoint presentation for the client that explains our final product and design process in a succinct manner, and a final report that does the same thing but in greater depth and scope.

**Constraints:**
There is a June 8th, 2013 deadline and a one hundred dollar project budget. In addition, we will have to consider government regulations, more specifically the risk of suffocation, strangulation, and injury of children and infants using the crib attachment. These regulations are set by the CPSC (Consumer Product Safety Commission).

**Users and Stakeholders:**
This crib attachment should first and foremost be usable by children from the ages of 0 to 3. In addition, the parents and possible sitters of the children who will purchase, install, and maintain the attachment will use it. If it is a successful product, KID will potentially market it and other companies might manufacture it.
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<td>Durability- Can be repeatedly abused by small children and adults</td>
<td>Mesh or other side on attachment can be stretched or pulled 10 times and not rip or break</td>
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<td>Social Interaction- Parents can lean on the crib and easily see their child even with the attachment</td>
<td>The child isn’t fully enclosed in the crib attachment and any barrier, cover, or side isn’t fully opaque</td>
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<td>Easily assembly- Cannot be put together in a way that makes it dangerous for the child</td>
<td>Any pieces or connections put together in an incorrect way will have visible warnings that inform parents of incorrect assembly</td>
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<td>Aesthetically Pleasing- Looks good enough to be purchase-able in a store</td>
<td>Utilizes multiple colors and has no aesthetic imperfections</td>
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<tr>
<td>Meets safety standards- Doesn’t fail to meet stringent safety requirements</td>
<td>CPSC safety standards met by the attachment’s design</td>
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Appendix B: Client Interview Summary

I. Problems
   a. The main problems with existing cribs include:
      i. Limbs of the children being caught between the slats
         1. Causes parents to try and put bumpers up
      ii. Falls
         iii. Entrapment
         iv. Side slats would break
         v. Cribs would fall apart

II. Standards:
   a. Are there any other problems we need to address in our design?

III. Requirements
   a. We know the crib must meet all CPSC’s mandatory safety requirements.
   b. Since we will not meet with the client until Friday we don’t know many of the requirements. These are some questions we plan on asking:
      i. Should the crib be full size?
         1. Does it need to be portable?
      ii. Is there a benefit to having slats over having some sort of mesh for the sides of the crib?
         1. Problems are
            a. How do you secure it?
            b. Durability
            c. Needs to stay very taught
               i. Mesh wrapped all the way around slat sides?
      iii. Needs to be visually appealing as well as safe
         1. No one will buy a cage for their babies
         2. Pilgrim’s Pride
            a. Glen Aaron
         3. Parents like to lean in to pick up or see their baby
      iv. How do children fall out of the crib? Do they climb out, and if so how?
         1. They climb out, either because walls are too low or objects inside of crib can be climbed over
      v. How much should the crib cost?
         1. ~$200.00 range
      vi. We might rework an existing crib instead of completely starting from scratch. Do you know where we could get one?
         1. Freecycle
      vii. Are there any additional requirements?
         1. Babies need to be able to be left alone in cribs
            a. Awake and asleep
         2. There needs to be proper ventilation in the crib for air flow
      viii. What we design just need to meet the durability requirements, not necessarily the definition of a crib
      ix. Sloping top
         1. Can’t collapse in on itself
2. Tent crib
3. Be wary that parents dislike fully closed cribs

IV. Users
   a. What is the age group of children who most commonly get their limbs stuck?
      i. 2-3
      ii. People put more than one child in the crib at a time
   b. Will users be assembling it or will it be assembled by a professional?
      i. Parents assemble cribs by themselves
      ii. Simple to construct
   c. Will it need to be disassembled and reassembled in order to be brought into the house?
      i. If yes, should we address these problems in our design?
         1. Crib needs to be easily assembled by parents with little mechanical skill
Appendix C: Crib Survey Questionnaire

1. This is the "swing crib." The base is stabilized by its weight and cannot be tipped over once the crib is set up. There is a mattress underneath the swingable crib in the circular base. The crib itself will be large enough for 0 to 3 year olds, and will restrict their ability to crawl out of the crib. Even if they manage to do so, they will fall into the underlying mattress.

![Diagram of a swing crib]

2. This is the four-cornered hammock. The mesh hammock will rest in the confines of the traditional crib bars. The mesh will be extremely taught, so that the baby can lie down flat without trouble; however, if he/she tries to crawl to the edges, it will be extremely difficult for them to succeed because the mesh will have a sloping incline.

![Diagram of a four-cornered hammock]

3. This is our most traditional option for the crib. The changes we made are: 1) The bars will be wrapped in mesh on both sides to prevent limbs being caught
in them, 2) There will be an overhang on top like a tissue box has so that the infant has difficulty climbing out and injuring him/herself, and 3) One side will have a lock and can be opened by a hinge to allow for easy accessibility to the infant without the danger of a "drop-down" side.

4. On a scale of 1 to 10, with 1 being poor and 10 being excellent, how do you like the aesthetics of each crib?

5. On a scale of 1 to 10, with 1 being poor and 10 being excellent, how comfortable would you feel leaving a child in each crib?

6. Please rank the above designs, with Rank 1 being your first choice, Rank 2 being second, and Rank 3 being third.
## Appendix D: Survey Results

### Aesthetics

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**Average Ranking - Aesthetics**

**Average Ranking - Safety**
## Appendix E: Alternatives Matrix

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<th>Pros</th>
<th>Cons</th>
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<tr>
<td>Find a used crib and use it for mockup testing and prototype construction</td>
<td>• Cheap&lt;br&gt;• Easier to demonstrate potential ideas&lt;br&gt;• Can test ease of construction</td>
<td>• Dirty finished product&lt;br&gt;• Crib needs to meet regulations&lt;br&gt;• Transportability is hampered</td>
<td>We find a used crib for sale or donation and we test out modifications to make the crib safer.</td>
</tr>
<tr>
<td>Create smaller, scale models of crib ideas and produce a scale prototype</td>
<td>• Inexpensive&lt;br&gt;• Easy to construct multiple shapes and sizes&lt;br&gt;• Clean&lt;br&gt;• Transportable</td>
<td>• Not full-size&lt;br&gt;• Construction difficult to demonstrate&lt;br&gt;• Freedoms in designing smaller models are restricted in full-size</td>
<td>We construct scale replicas of potential crib shapes and produce the cleanest models of our prototype as we approach our final design.</td>
</tr>
<tr>
<td>Buy a new crib, make modifications as necessary, and use it for the final prototype</td>
<td>• Crib likely to meet regulations&lt;br&gt;• Starts off clean&lt;br&gt;• Can test ease of construction</td>
<td>• Most expensive option&lt;br&gt;• Transportability is still an issue&lt;br&gt;• Won’t remain pretty after mockups</td>
<td>We buy a new crib and make a few modifications to it in order to produce a safer crib.</td>
</tr>
</tbody>
</table>
Appendix F: Design Review Summary

Date: May 16th, 2013

- Lobster Trap
- Slant the sides of the crib
  - Thick rim along the top
- Bed Barrier
- Think mesh laundry hampers
- What about replacing mesh?
  - Mesh screens
  - Loop around each corner
    - Hooks
  - Insert mesh pocket
- Butterfly-fish net

Incorporate the following:
1. Mesh pocket
2. Solid frame
3. Curved rim along top frame

Metal rods with mesh
- Loops in mesh to contain metal rod
- Hooks on crib to set rod on
- Device on top to keep rod down
Appendix G: Client Feedback

Email from Jason to Nancy:

Hi Nancy,

Attached are our top three designs for the crib. We are wondering if you could look over them and give us your input, specifically about the possible safety shortcomings of any of the designs. Also, do you have any input for what type of mesh to use in our designs?
Email from Nancy to Jason:

Thanks for sending this. I don’t have any specific recommendations for mesh. The requirements would be that the mesh be strong, the holes in it too small to entrap even a baby finger. It also needs to be installed in such a way that it can’t be pushed out and form a pocket next to the mattress where a baby could be caught.

For the egg shaped product, I’m worried that while it would work for a tiny infant, an older baby, who could stand for instance, would easily get out of the inner part. I may just need you to describe it to me.

Would you like to review this via phone or a meeting? I’m out of town this weekend but could talk Monday.

Sent from my iPad

Nancy Cowles

Kids In Danger

312-218-5593
Appendix H: Building Instructions for Prototype

1. Cut 6 pieces of balsa of the following dimensions: 3 inches wide, 3 inches tall, and 2 inches deep.
2. On a mill, drill a half-inch wide, 2-inch deep hole a quarter-inch from the bottom left corner (if facing the 3X3 inch face) in 3 of the 6 pieces of balsa.
3. On the other 3, drill from the bottom right corner. Now with each of the six pieces, drill a channel one-eighth of an inch wide from the bottom of the piece into the holes drilled in this step and step 2. This channel should go along the length of the piece, so 2 inches.
4. Pick two balsa pieces from step 3, and two from step 4.
5. Into the two from step 3, drill a half-inch wide, 2-inch deep hole in the upper left corner of one piece. And in the upper right corner of the other.
6. Into the two from step 4, drill a half-inch wide, 2-inch deep hole in the upper left corner of one piece. And in the upper right corner of the other.
7. Into each balsa piece, cut a 0.9-inch wide and 1.5-inch deep section of wood out from the bottom of the piece. (The bottom being the same bottom referred to in steps 2 and 3).
8. Cut out 1 section of canvas, 52 inches by 28 inches.
9. Cut out 4 strips of canvas, 6 inches by 28 inches.
10. Cut out 2 sections of canvas, 4 inches by 28 inches.
11. Cut out 2 sections of canvas, 4 inches by 52 inches.
12. Cut out 2 sections of mesh, 28 inches by 2 inches.
13. Cut out 2 sections of mesh 52 inches by 28 inches.
14. Sew the sections of canvas from steps 10 and 11 into loops.
15. Sew bottom of the longer sides of mesh from steps 12 and 13 to the edges of the section of canvas from step 8.
16. Sew the top of the longer sides of mesh from steps 12 and 13 to the loops created in step 14. (Match up the dimensions of lengths of sides).
17. Sew the 4 sections of mesh from steps 12 and 13 together to form a box-shape using the canvas sections from step 9 as a seam.
18. Insert the dowel into the 4 loops of canvas from steps 10 and 11.
19. Thread 2 rods and attached mesh through the holes and channels in the bottom of the 6 balsa wood pieces.
20. Insert 2 rods with mesh attached into the holes of the 4 pieces with holes drilled at the top.
21. Sit the 6 pieces on the crib walls, the longer walls. The 4 pieces with holes in the tops and bottom should go in the corners. Arrange them so that the top holes on each of the 4 face into the crib, not out, and that the side they are on is the side closes to the head and foot boards. The remaining 2 should be placed in the middle sections of each long wall. One on each side. Each piece should be oriented so that the bottom channel is inside the crib, not out. So the mesh inserted rod is inside, and the mesh flows down into the crib.
### Appendix I: Bill of Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Cost Per</th>
<th>Part #</th>
<th>Vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maple Dowel-48” long, ¼” diameter</td>
<td>4</td>
<td>$1.11</td>
<td>907015K13</td>
<td>McMaster.com</td>
</tr>
<tr>
<td>Linear Yard of Canvas</td>
<td>3</td>
<td>$3.00</td>
<td>5857K11</td>
<td>Vogue Fabrics</td>
</tr>
<tr>
<td>3” by 3” by 6” strip of Balsa</td>
<td>8</td>
<td>$6.35</td>
<td>5068K42</td>
<td>McMaster.com</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Power Net Mesh - White</td>
<td>Rockywoods.com</td>
</tr>
<tr>
<td>Linear Yard of Mesh</td>
<td>3</td>
<td>$8.99</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The material names and quantities are specific to the project requirements. The cost per unit and part numbers are from the respective vendors. The vendors include McMaster.com and Rockywoods.com.