DREAM DOCTOR©

Final Product and Production Report

DEPARTMENT OF HUMANITIES AND APPLIED LANGUAGES
SCHOOL OF BUSINESS
INSTITUTE OF TECHNOLOGY CARLOW

B.DES (HONS) INDUSTRIAL DESIGN.

HONOURS DEGREE PROJECT

2005/2006

Dream Doctor

PROJECT REPORT

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SUBMISSION DATE: 16th May 2006

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1.0 Introduction

1.1 The project

Hypothesis:

- Is it possible to re-design a home peritoneal dialysis machine aimed at children that will take into consideration problems specific to them?

More specifically, would it be possible to create a product that could increase the quality of life for a child on dialysis, as this is a very intrusive and overwhelming treatment.

Project background:

Dialysis is a medical process through which a person's blood is cleansed of the toxins the kidneys normally would flush out. It is generally used when a person's kidneys no longer function properly. This can be a result of congenital kidney disease, long-term diabetes, high blood pressure or other conditions.

The number of cases of dialysis in Ireland has increased by 33% in the last three years. Similar statistics can be seen across Northern Europe. A gap has been identified in the market for a dialysis machine aimed specifically at children who use peritoneal dialysis in the home.

1.2 Research conclusions

- The existing machine uses a very complex line system, which takes up to 20 minutes to set up.
- Peritonitis is a very serious infection associated with peritoneal dialysis, this is due to the number of connector sites, which the patient must come into contact with in order to set up the machine.
- The treatment system is also very complicated and the patient has to be trained for two weeks prior to treatment in order to be able to deal with the problems, which arise.
- It is also a very heavy cumbersome piece of equipment which is designed to sit on a table at the bedside, this makes it impossible for the patient to get up and move around, and this is unacceptable as during the early stages the treatment can last for up to 18 hours.
- The treatment a child receives is significantly different to adults in terms of volume of dialisate needed.
- The technology used in the existing machines is outdated and has not been improved for over 15 years.

1.3 The project brief

Brief:

Re-design a home continuous cycler-assisted peritoneal dialysis machine aimed at children that will take into consideration problems specific to them and improve their quality of life.

End-user:

- The product is aimed at children who are using dialysis treatment. These children tend to be smaller than children of a similar age not on dialysis.
- The target market is Northern Europe, with the key countries being France, Italy, Portugal, Great Britain and Ireland.

Product environment:

- The product is to be used in the home environment. It will primarily be used in the bedroom, however it should have a portability option as treatment can last for up to 18 hours during the early stages of treatment.
- Sleep disturbance is an issue associated with these products; the new product should take this into consideration and enhance a sleep like atmosphere where possible.

Interface:

- The interface should be made as simple as possible using only symbols to instruct the child during treatment.
- A new patient card will hold all data relevant to the treatment prescribed by the doctor.

Form:

- There is potential for a dominant branding presence as competition has a poor branding strategy.
- The product should have aesthetic appeal.

Ergonomics & semantics:

- The final form should be sympathetic toward relevant anthropometric data.
- The product semantics will play a large role in how to use the new product. The final design should incorporate intuitive and instinctive product semantics.

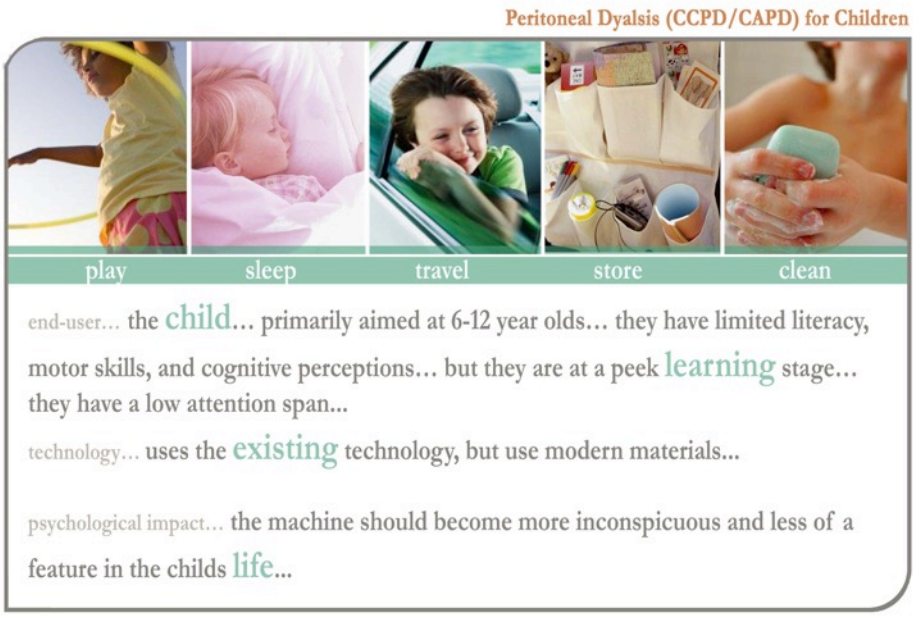
Sustainability & safety:

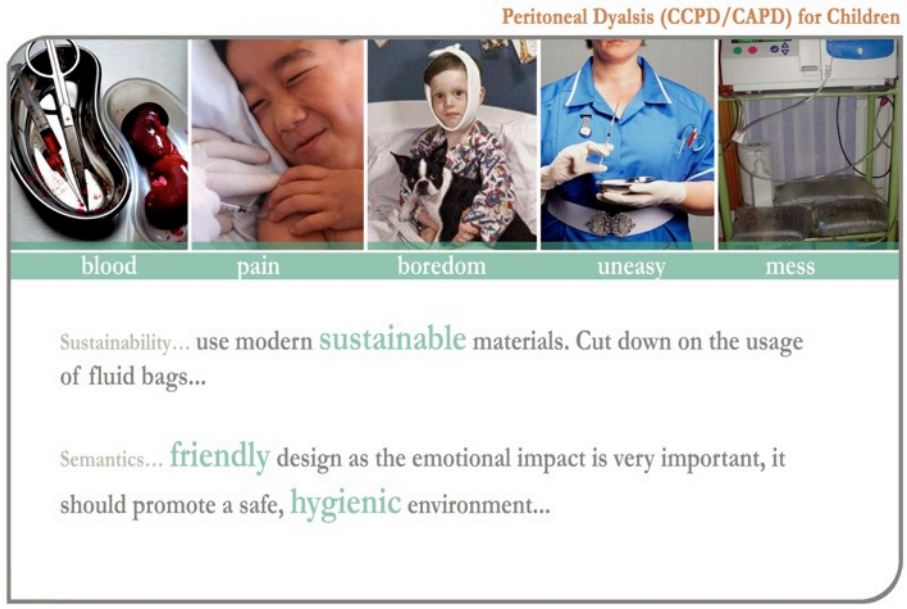
- The solution must comply with European Sustainability Standards, and be Energy Efficient. In respect to portability, renewable energy sources should be investigated, with the aim of supplementing/sustaining power.
- All components are required to obey EU Safety Standards.

Implementation:

- The primary product production batch will amount to 1,000 units, and be circulated amongst qualified practitioners. During this market-testing phase, vital product feedback will be accumulated with the intent of catering for the typical, unqualified end-user.
- A second batch of 20,000 units will enter the European market with intent for a more widespread audience. Production will fluctuate according to demand.

- The final product will be a dramatically improved version of an old product however it will have a niche, as it is the only one designed for children. It will be marketed as a high technology, high-design, and life-improvement solution.





1.4 The result

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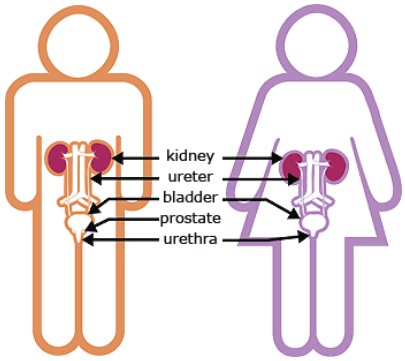
2.0 Final design configuration

2.1 Product proposal

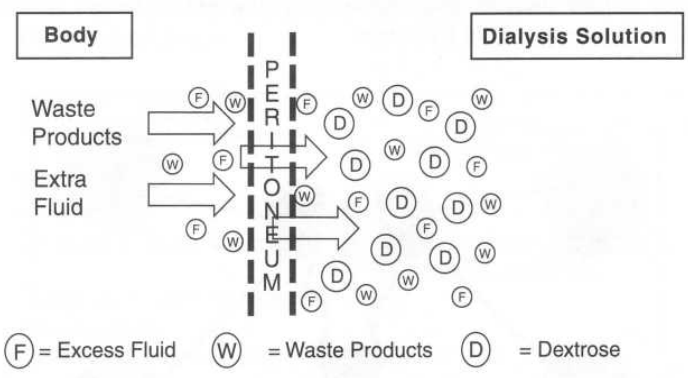
A Home Cycler-Assisted Peritoneal Dialysis (CAPD) Machine

for children suffering from kidney failure.

Dialysis is the treatment used when the kidneys are unable to carry out their normal functions of filtering the blood of toxins and wastewater.



Peritoneal dialysis takes place inside the body; it uses the patient's natural peritoneal membrane to filter the blood. A solution called dextrose is held within the peritoneal membrane for approximately 40 minutes, during this time it draws the toxins and waste fluid from the blood through a process called diffusion and osmotic pressure. This is then drained from the abdomen and discarded as waste. This cycle continues 4 or 5 times during the night, it can take from 10 hours to 18 hours during the early stages of treatment.

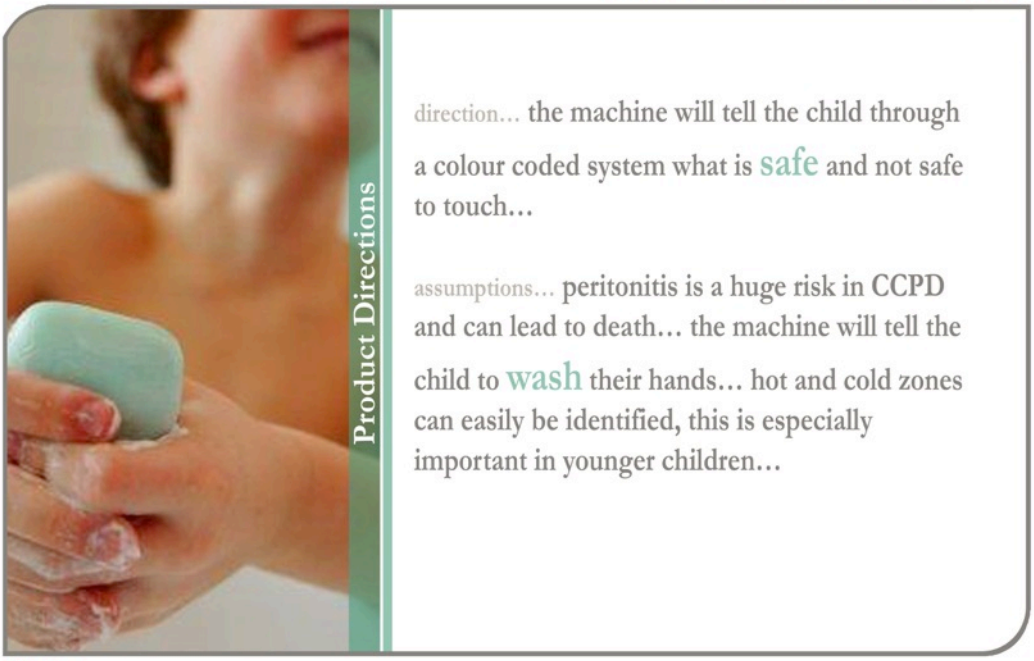


CAPD uses a machine to control the treatment while the child sleeps; it takes place in the patient's home. CAPD machines currently on the market require up to 5 separate dextrose bags and a complicated line set to be hooked up to the machine for each treatment this can take up to 20 minutes to set up. There is no storage area for these bags and the machine is not portable. Peritonitis is a dangerous infection associated with peritoneal dialysis the most common infection sites are at the connectors between the bags and the line set, there are up to 7 of these on existing machines.

Existing machine, photo taken in the patient's home environment - you can see that they have acquired a trolley so as to be able to move around.

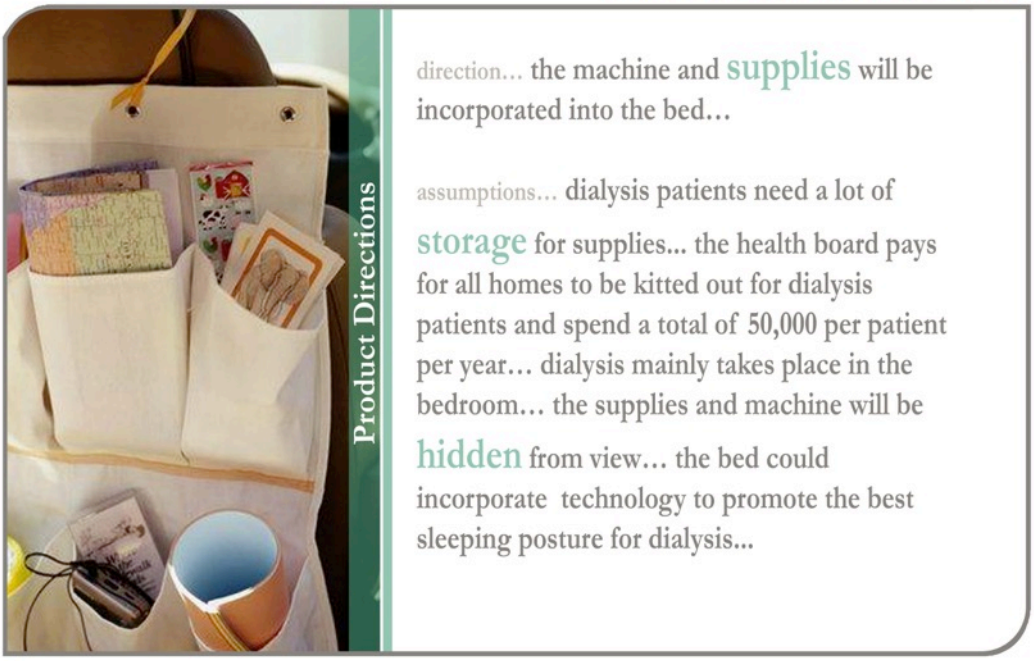
2.2 Concept generation and development

Peritoneal Dyalsis (CCPD/CAPD) for Children



Clean

Peritoneal Dyalsis (CCPD/CAPD) for Children

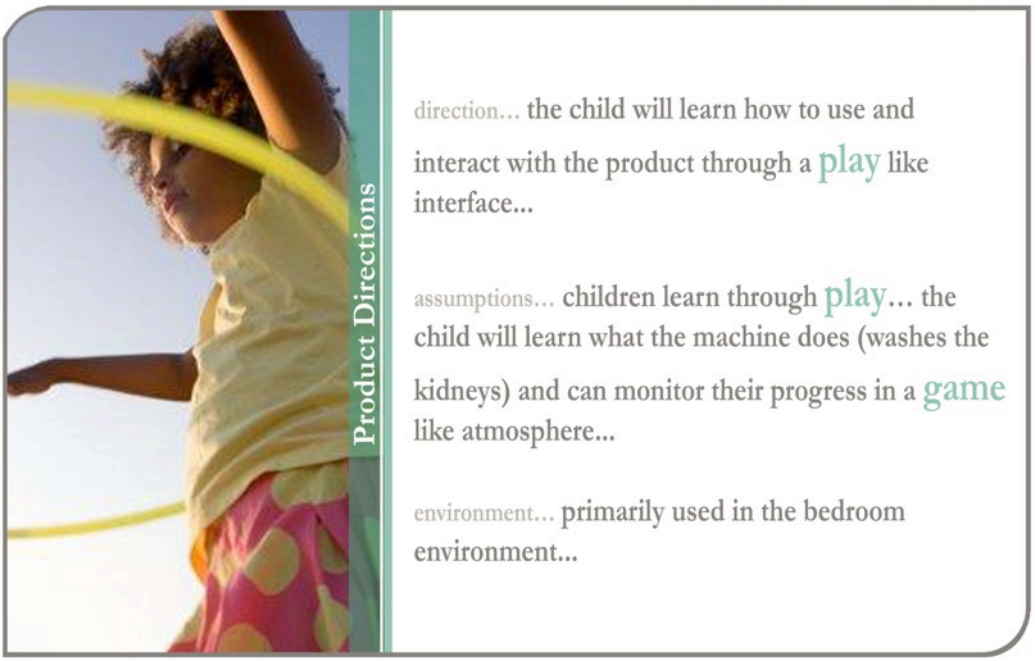


Store

Peritoneal Dyalsis (CCPD/CAPD) for Children

Sleep

Peritoneal Dyalsis (CCPD/CAPD) for Children



Play

Peritoneal Dyalsis (CCPD/CAPD) for Children

Product Directions

direction... the product is easily portable in a number of modes of transport...

assumptions... the child needs less fluid than adults so the machine can therefore be made smaller and lighter...a child on dialysis may hold a family back from going on holidays which can lead to resentment from other siblings... the child may have to make frequent trips to the hospital with the machine... the case could fold out into a stand...

environment... its must fit in a car, bus, train and plane...

Travel

Peritoneal Dyalsis (CCPD/CAPD) for Children

Criteria	play	sleep	travel	store	clean
Sustainability	0	0	0	0	0
Portability	0	0	+	-	0
Hygiene	0	0	-	0	+
Ease of use	+	+	0	0	0
Environment	+	+	+	+	+
Interface	+	+	-	-	+
User comfort	+	+	0	+	0
Originality	+	+	-	+	-
User interaction	+	+	+	0	0
Total	6	6	0	1	2
Rank	1	1	5	4	3
Result	PLAY	SLEEP	CLEAN	STORE	TRAVEL

2.3. Benchmarking and style

2.4 Chosen concept

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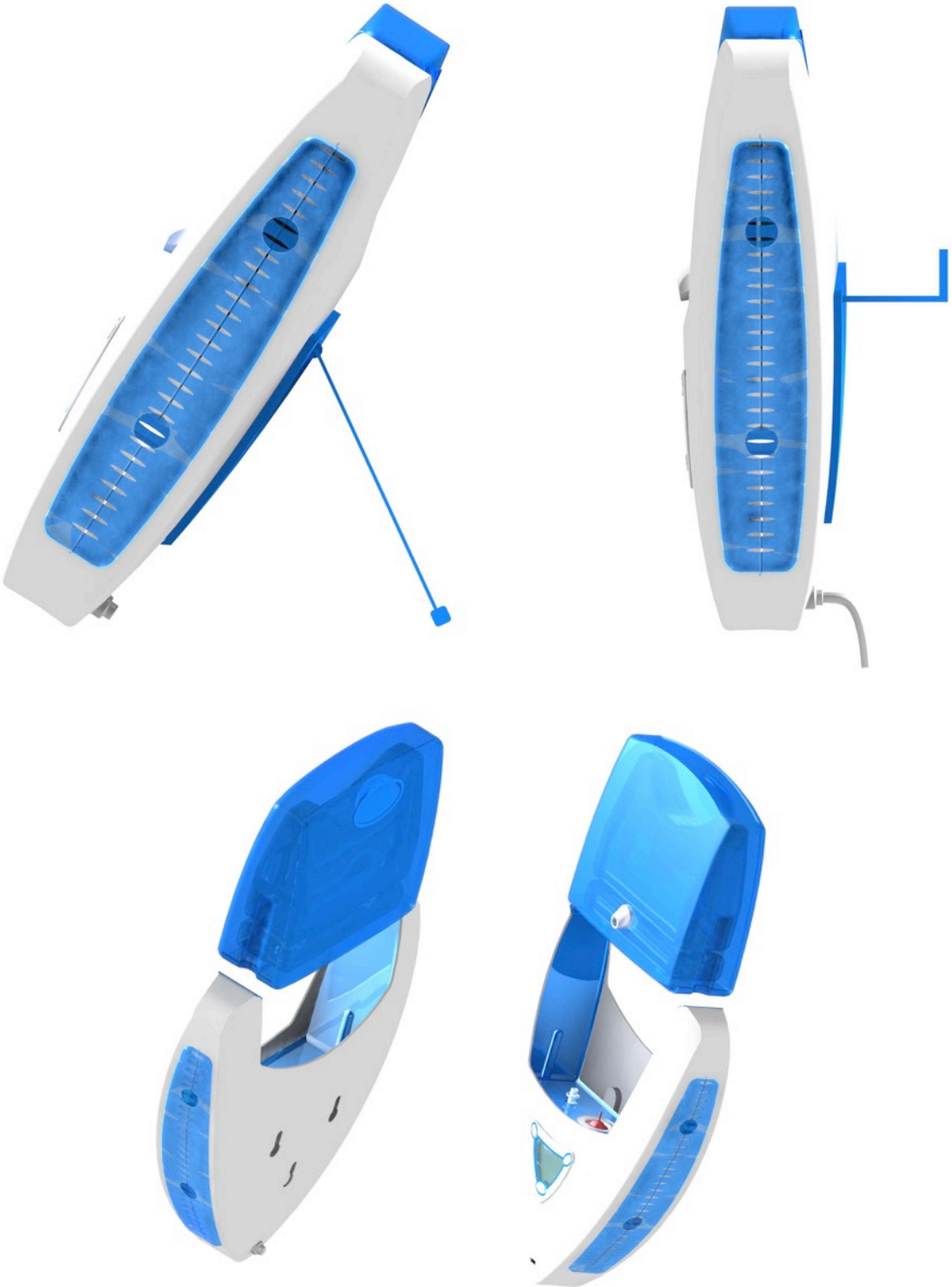
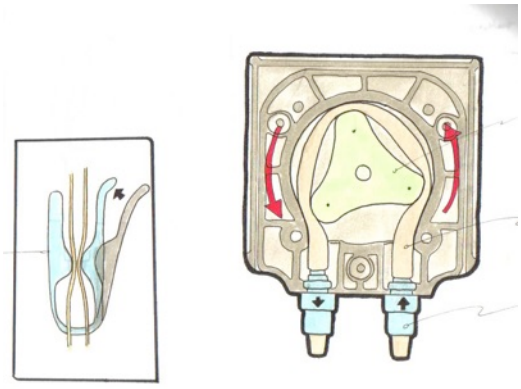
The DREAM DOCTOR machine uses just one fluid pack containing a sterilised water bag with the required electrolytes, buffers and osmatic agents, the pack also contains a separate mixing bag. This cuts the instances of peritonitis infection sites from 7 to just 1, as there is just the patient line to be attached to the machine. The machine now takes seconds to set up, and is portable enabling the child to move around freely meaning they are not restricted to their bed. It can also be taken off the stand and placed on a tabletop; this can be a good feature if the child is away from home. No storage area is needed as everything is contained in the one pack.



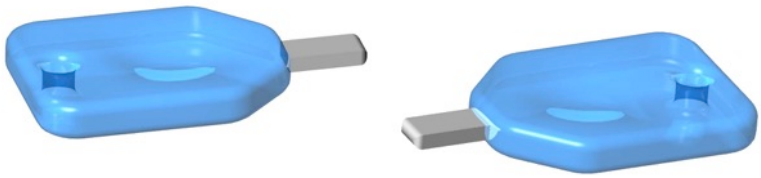
How it works

A peristaltic pump controls fluid flow from the sterilised water bag to the mixing bag. The machine pumps the required amount of sterilized water into the mixing bag; a separate cartridge containing dextrose in a powder form injects the prescribed amount into the bag. This is then mixed and heated using ultrasonic waves. A valve releases the fluid into the patient line. The patient's peritoneal membrane fills with the fluid, the valve closes and the fluid is held there for the required time, when the valve opens it creates a negative pressure causing the fluid to drain from the child's abdomen and into the waste line. This cycle continues through the night up to 5 times, an alarm sounds to alert the patient if there is a problem with the machine such as an obstruction in the line, which can happen if the patient lies on it.



Features and functions

A new treatment card is inserted into the machine, this contains the therapy settings prescribed by the physician and the card also records treatment results form the therapy.



The product is designed for children, it uses simple semantics and symbols so that the child can use and understand the machine. The machine is designed to fit into the child's environment, while not being obviously medical it is still clear that it is not a toy. It promotes a sleep like atmosphere as most CAPD machines can disturb sleep. A polychromic colour changing plastic night light is incorporated into the machine this gives a soft gentle light, it lets the child locate the machine and see that it is working even in the dark. This light flashes and an alarm sounds to wake the child when there is a problem.

2.5 Branding

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BAXTER HOMEhealth

2.6 Product form – the aesthetic

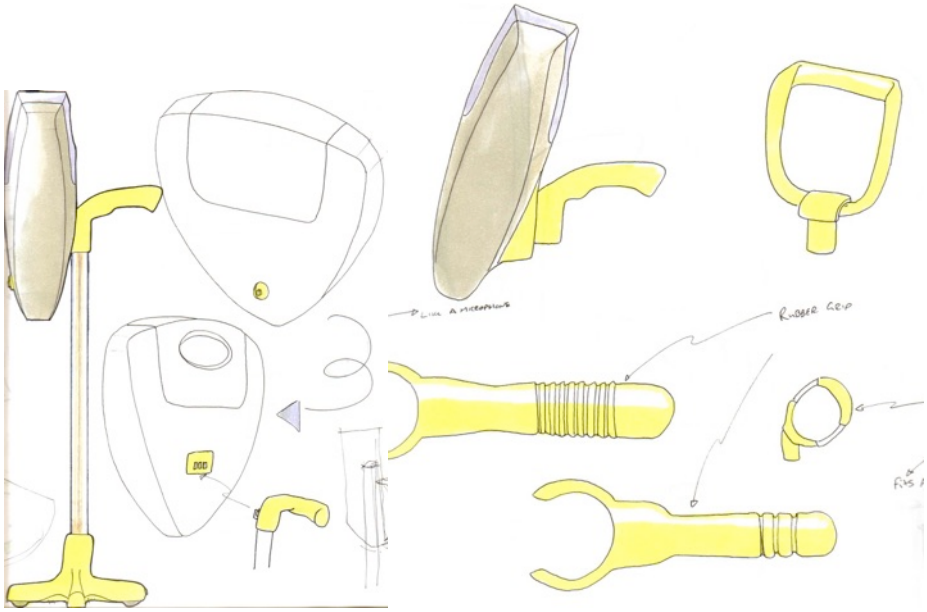
The final aesthetic was chosen to portray a medical device which was approachable and easy to use but which also commanded respect from the user. The product is viewed as a helpful and very hygienic product. The product is predominantly white as this will enhance the hygienic element in the design, it will make dirty surfaces easier to spot to promote frequent cleaning of the machine.

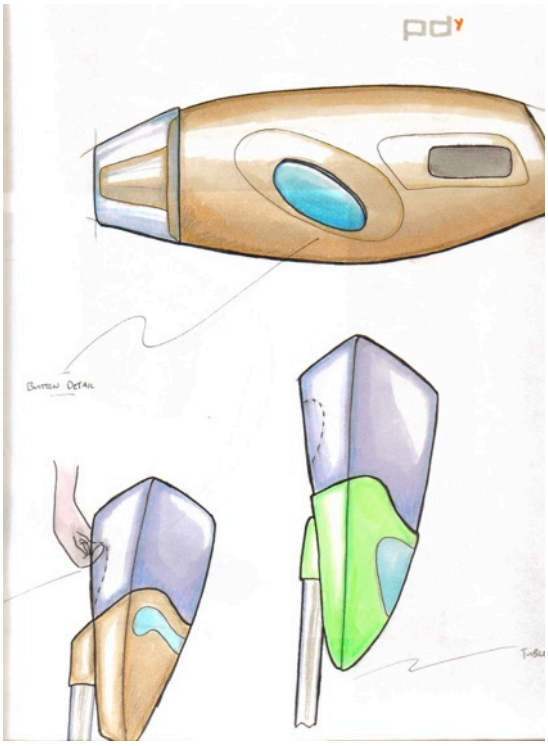
2.7 Ergonomics

Interface design

The position of labels with text or icons is crucial for an unfamiliar user. All too often labels are positioned in a way that they are obscured from the user's view when the controls are being operated.

It was decided that the user should know which controls are active at any one time. This is done by internally illuminating active keys. Blinking indicators are restricted to situations requiring immediate action by the user; and also to indicate that the treatment is ready to start or finish, in these cases, they are accompanied by an auditory signal. The shape of the button is used to help the user associate the function with the key. Simple symbols are used in order for the child to understand what is happening and they can track their treatment.





Handle sizes and grips were investigated to determine which was most ergonomically correct for children. A handle was decided that which would allow the child to both push and pull the product as preferred by the child.

The line attachment has grips incorporated into the design to allow easier grip for the child.

3.0 Design for market

3.1 Background market data

Chronic kidney failure is a condition that affects more than 1,300,000 individuals worldwide. There has been a 33% increase in kidney patients on dialysis treatment in Ireland over the past three years, according to new statistics from the Irish Kidney Association (IKA).

The market is expanding and as the economy grows the need for private and more personal healthcare will rise. There is no CCPD machine aimed specifically at children. An opportunity exists to manufacture home-based dialysis products for children. The machines will be sold in Europe with Germany, France, Italy, England and Ireland being the main focus of sales. The product will be marketed under the existing healthcare company Baxter, however a new sub division will be created aiming its products specifically at the home environment. The new division will be called Baxter Homehealth. The machines will be sold to health boards and heavily promoted using the new easier functions and elimination of the complex line system.

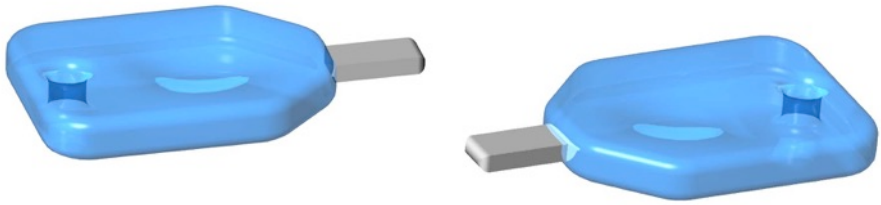
The future of dialysis

In 5-10 years, the baby boomer generation will enter the age of organ degeneration and diseases. Based upon a population growth rate of 7% and an end of 2000 worldwide population of 1,060,000, it is estimated that by 2010, the worldwide dialysis population will double. There will be a blaring need for new therapies, considering the cost of treatment and stagnant quality of life.

3.2 End users

The nephrologist

A nephrologist is a doctor who treats kidney diseases and kidney failure. The nephrologist may prescribe treatments to slow disease progression and will determine when referral to a transplant centre or to a dialysis clinic is appropriate. The new treatment key will enable the doctor to track the patient's treatment much easier.



The dialysis nurse

A nurse with special training will make sure all procedures are followed carefully. The dialysis nurse will train the user so they feel comfortable doing the exchanges at home.

The patient

The child is the main user as it is they undergoing the dialysis process. They must fully understand what is happening and what to do if something goes wrong. They

must be thought about the importance of hygiene. The product helps them understand by using simple symbols and semantics to guide the child through the treatment.

The family members

The child's parent will be the one doing the initial exchanges and teaching the children how to do it themselves. They will have to fully understand the process and how to identify and solve problems if they occur.

3.3 Social factors

The dialysis process is extremely unsociable. Many patients have long and frequent hospital visits. Many patients feel tired and unwell while receiving dialysis treatments and are limited in the activities they can partake in. The existing machines in the patients home are very heavy and bulky. Dialysis takes up a huge amount of time from the child's life daily. The new product is less intrusive on the patient's life; it blends into the child's environment and does not attract too much attention to itself or the process it is performing.

3.4 Hygiene factors

Peritonitis is an infection of the peritoneal membrane. It is the major complication of peritoneal dialysis. The introduction of germs into the peritoneal cavity causes peritonitis. Peritonitis can become a life-threatening situation if left untreated. Therefore, every precaution should be taken to ensure that it does not develop. Peritonitis occurs when there has been a breakdown in the exchange procedure and peritoneal dialysis associated techniques. The new dream doctor reduces the risk of peritonitis by 70%.

4.0 Design for manufacture

4.1 Materials and manufacturing processes

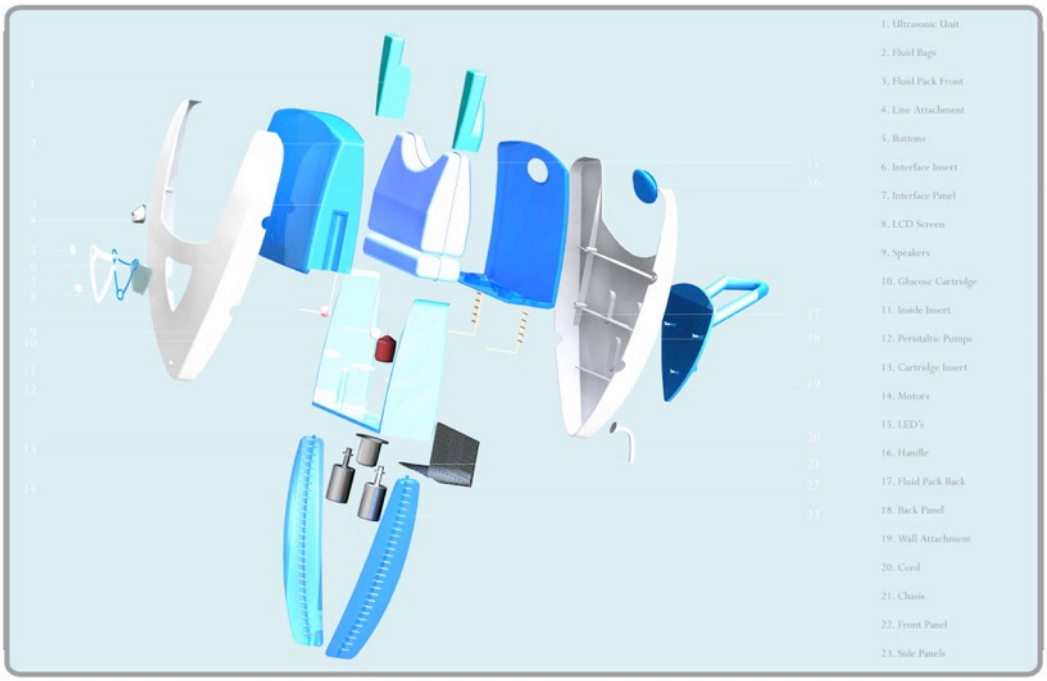
Component	Custom/Sourced	Material	Manufacturing Process
 Back panel	Custom	Acrylonitrile butadiene styrene (ABS)	Injection Moulded
 Fluid packs	Custom	Polyvinylchloride PVC	
 Base	Custom	Acrylonitrile butadiene styrene (ABS)	Injection Moulded
 Buttons	Custom	Polyproplene PP	Injection Moulded
 Cartridge	Sourced	N/A	N/A
	Custom	Acrylonitrile butadiene styrene	Injection Moulded

Cartridge insert		(ABS)	
 Chassis	Sourced	Aluminium	Machined
 Cord	Sourced	Acrylonitrile butadiene styrene (ABS)	N/A
 Fluid pack back	Custom	Polyethylene (PE)	Injection Moulded
 Fluid pack front	Custom	Polyethylene (PE)	Injection Moulded
 Front panel	Custom	Acrylonitrile butadiene styrene (ABS)	Injection Moulded
 Handle	Custom	Acrylonitrile butadiene styrene (ABS)	Injection Moulded
 Interface insert	Custom	Polyproplene PP	Injection Moulded
	Custom	Polyproplene PP	Injection Moulded

Interface panel			
 LED's	Sourced	N/A	N/A
 Line attachment	Custom	Acrylonitrile butadiene styrene (ABS)	Injection Moulded
 Middle	Custom	Acrylonitrile butadiene styrene (ABS)	Injection Moulded
 Motors	Sourced	N/A	N/A
 Fluid pack handle	Custom	Rubber	Injection Moulded
 Interface panel	Sourced	Glass	N/A
 Pole	Sourced	Aluminium	N/A
Peristaltic pumps	Sourced	Acrylonitrile butadiene styrene (ABS)	N/A

 Side panels	Custom	Acrylonitrile butadiene styrene (ABS)	Injection Moulded
 Speakers	Sourced	N/A	N/A
 Table stand	Custom	Acrylonitrile butadiene styrene (ABS)	Injection Moulded
 Ultrasonic unit	Sourced	N/A	N/A
 Wall Mount	Custom	Acrylonitrile butadiene styrene (ABS)	Injection Moulded
 Wheels	Sourced	Acrylonitrile butadiene styrene (ABS)	N/A

Bill of materials and exploded drawing



Identification of features, which facilitate assembly/disassembly for recycling

4.2 Costing

Component	Material	Assembly	Processing	Total unit variable cost	Tooling cost	Total unit production	Total unit fixed cost	Total cost
Ultra sonic unit				0.15		10000		0.15
Fluid bags	0.5	0.16	0.15	0.81	11	10000	2.2	3.01
Fluid pack front	0.56	0.16	0.15	0.87	16	10000	2.3	3.17
Line attachment	0.13	0.2	0.15	0.48	2	10000	1.2	1.68
Buttons	0.13	0.2	0.15	0.48	2	10000	1.2	1.68
Interface design	0.24	0.2	0.15	0.59	3	10000	1.4	1.99
Interface panel	0.24	0.2	0.15	0.59	3	10000	1.4	1.99
LCD screen	0.13	0.2	0.15	0.48	3	10000	1.4	1.88
Speakers				0.3		10000		0.3
Glucose cartridge				0.7		10000		0.7
Inside insert	0.6	0.18	0.15	0.93	14	10000	2.3	3.23
Peristaltic pumps				0.2		10000		0.2
Cartridge insert	0.3	0.18	0.15	0.63	12	10000	2.2	2.83
Motors				0.2		10000		0.2
LED's				0.2		10000		0.2
Handle	0.36	0.14	0.15	0.65	12	10000	2.2	2.85
Fluid pack back	0.56	0.16	0.15	0.87	16	10000	2.3	3.17
Back panel	1.4	0.3	0.15	1.85	20	10000	2.6	4.45
Wall attachment	0.4	0.2	0.15	0.75	18	10000	2.4	3.15
Cord	0.13	0.2	0.15	0.48	3	10000	1.1	1.58
Chassis				0.2		10000		0.2
Front panel	1.4	0.16	0.15	1.71	20	10000	2.7	4.41
Side panels	1.2	0.16	0.15	1.51	18	10000	2.5	4.01
Overheads								18.81
Total cost				15.63			31.4	65.84

5.0 Conclusions

The DREAM DOCTOR machine replaces a very complicated and time consuming set up system with just one pack. This reduces the risk of peritonitis infection by 70% as the number of connector sites has been reduced from six to one. Also set up time has been reduced from 20 minutes to 3 minutes.

The machine uses simple symbols and semantics to guide the child through the treatment process. It attaches to a trolley, which enables the child to move freely during what can be an 18-hour treatment during the early stages.

It is the only dialysis product designed for children taking into account their specific needs. The machine enhances sleep as a night-light is incorporated, which is also incorporates changing colours to indicate to the child what stage they are at in the treatment.

5.2 Identification of future features of the product

- Varied colour styling and mass customisation considerations
- Different model versions aimed at adults
- A carrying case to enable the child to bring the machine on holidays
- An APD backpack dialysis system to enable the child to use daytime hours