Accessible Syringe Dosing Device

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I. STATEMENT OF NEED

In recent years, many independent adults have indicated a need for a method of accurately controlling the doses of their intravenous medications. Millions of people rely on self-medicating techniques that require the use of syringes. Those suffering from type II diabetes, and therefore are insulin dependent, or stroke patients, who use precautionary heparin injections, are some of the patients who most commonly use syringes. Self-dosing can be problematic for many people, especially those who are elderly, visually impaired, or hearing impaired, or suffer from arthritis, Parkinson’s disease, partial paralysis, or the loss of motor skills due to a stroke, heart attack, or other physical ailments. Clearly, there is a need for a reliable, easy-to-use, and inexpensive product to accurately fill syringes with insulin or heparin in a timely manner.

Products currently on the market require patients to mechanically fill their syringes, using their fine motor skills to control the syringe mechanism. This method increases the risk of errant dosing by relying on the patient’s physical ability to perform the dosing correctly. The current products, therefore, do not accommodate patients that lack the fine motor skills necessary for correct use. The product described here will provide a digital self-dosing device that will accommodate many of the physical limitations mentioned above, while remaining affordable and competitive in today’s market.
II. BASIC PRELIMINARY REQUIREMENTS

This new product has several important basic requirements. It needs to be accessible for people who are hearing impaired, vision impaired, and who lack certain motor functions. Because most of the products already on the market accommodate those who are hearing impaired and vision impaired, the feature that will set this product apart from the others is that it will not require fine motor skills for operation. It must, of course, accurately dose the user’s medication to the nearest 0.01cc. The accessible syringe dosing device must also, as its title implies, be compact, easy-to-use, and cost effective. In order to design such a device, the team of project engineers will employ their knowledge in the areas of control, digital electronics, computer programming, instrumentation, and other essential branches of traditional engineering in addition to the application of the principles of biomedical engineering.

III. BASIC LIMITATIONS

There are certain problems in the design and analysis of the syringe dosing device that must be addressed. Reliability is perhaps the most prominent of these problems. It is necessary that the patient’s dose be correctly measured within 0.01 cc. Durability of the product will also be very important; this product must have the ability to withstand the force of a fall from approximately five feet onto a hard surface. Additionally, in terms of marketing, the cost of this product must be comparable to or lower than similar products on the market.

One problem that may arise the design process is that of incorrect dosing due to the initial force of the device’s motor. If the motor initially jerks or slowly gets up to speed, this inconsistency will affect the reliability of dosing. Aside from this, the gear ratio needs to be
precisely determined in order for correct dosing. The gears need to be light, but have a very long
and reliable life. Since the device will be digital, its programming must be devised and
perfected. The program must accommodate the motors and gears of the device in order to ensure
accurate dosing.

Another dilemma that may be encountered during the design process is the matter of the
power source of the device. There are many batteries to choose from, and because this product is
a medical device, it must have a reliable power source. Employing a battery that is easy for the
consumer to find in a local store would be ideal if feasible. When the battery needs to be
changed, engineers should not need to be deployed; this instrument must have an easy outer
compartment for easy changes. Lastly, the device should not function differently when the
battery is low, and a low battery indicator needs to be created to warn user. Such an indicator
may require additional circuitry.

Ease of use is very important to syringe dosing. This medical instrument is being
designed for a variety of persons with disabilities. Sound must be implemented within this
device for the blind, requiring additional circuitry. The syringe dosing must not need more than
minimal strength to use in order to accommodate people with arthritis or limited muscular or
motor function.

IV. CLIENTELE

The principal clientele for this project as established by the Rehabilitation Engineering
Research Center on Accessible Medical Instrumentation are Lloyd, Sophia, Arnold, Dave, and
Wanda and her father Bob. These imaginary clients are designed to emulate the characteristics
and conditions that a typical client of our product would exhibit. Each client is different,
possessing unique needs that add to the general product stipulation. The following is a summary of the traits that we feel are most important when considering our design.

Lloyd suffers from type II diabetes and therefore is interested in our product as a convenient method for dosing the syringes used for her insulin injections. She already has poor eyesight and is nearing 80 years old. In the coming years, her eyesight, hearing, and motor skills may further diminish. In terms of our design, this stipulates that our product should accommodate those who are elderly and who have poor vision. The product must be easy enough to use while not relying on sight to determine the dosing.

Sophia, also around 80 years of age, is a victim of one large stroke and several smaller ones. Because of the risk of recurrence, she now uses heparin injections and therefore requires an accessible dosing mechanism. She has limited use of her right arm and therefore may have a hard time operating a device that requires either fine motor coordination or the use of both hands. The product should therefore accommodate these limitations by limiting, or perhaps eliminating, the need for fine motor functions.

Arnold is also a victim of diabetes and therefore requires insulin injections. He is about 50 years of age, and his fine motor functions are handicapped by the tremors that result from Parkinson’s disease. This once again advocates the need for a dosing device that does not require fine motor skills to operate.

Dave also suffers from type II diabetes and has limited leg mobility. The device should therefore be easily portable to add to its convenience and thus minimize necessary movement.

Wanda also suffers from diabetes. She is only ten years old and despite being deaf is being encouraged to start self-administrating her insulin injections. Her father, Bob, is her sole caretaker and is responsible for teaching her how to administer these injections; however, he is
limited by blindness. The device should therefore once again accommodate patients with loss of sight as well as those will loss of hearing.

   Based on the needs of our clients, our product must accommodate sight and hearing impairments, must be functional even for those with limited motor functions and mobility, and must be easy to use by people of all ages.

V. COMPETING PRODUCTS

   The following is a compilation of several of the principal competitors currently on the market. For our design it is necessary to note the good points of such products as well as the shortcomings upon which we can improve. The retail price of each is also an important figure, as it dictates the budget within which we are to produce a competitive product. Also, any additional information about these products that we feel necessary when considering our own design is included below.

   Count-A-Dose by Medicool: This product priced at $59.95 is not only the most popular one on the market, but is also the one that best satisfies our requirements. It is lightweight, portable, and easy to use. It accommodates sight and hearing impaired patients by using a clicking sound that can be felt and counts the dosing units. It even has a two-insulin bottle holder at its base for easy mixing. The product is visually appealing and includes a tape cassette with instructions. The product, however, can be improved upon. It only adds to the syringe in 1-unit increments and therefore can be a hassle while dosing. Furthermore, it still relies on a patient’s ability to use fine motor functions in operating the device. It also does not aim to minimize human error in dosing amounts. There is no definite indicator of the dosing on the device; rather it relies on the client's ability to count the clicks. This may be problematic with
patients with bad memories or attention disorders. Our device should therefore embody the
Count-A-Dose’s basic design while increasing its functionality to encompass the stated
shortcomings.

Load-Matic by Palco Labs: This product is priced at $49.95 and is very similar in
appearance and aesthetics to the aforementioned Count-A-Dose. The design, however, is far
more complex; the Load-Matic includes increment settings of either 1 unit at a time or 10 units at
a time, using a movable operating drill gear. Although this does have some advantages, it also
leads to more error in dosing. The 10-unit lever is not easy to fully depress, especially for clients
with limited motor functions, and therefore under dosing is a recurring problem. Also, like the
Count-A-Dose this device fails to minimize the human mechanical interactions and therefore
needlessly increasing the risk of error. Our device should continue with the Load-Matic’s trend
toward a quicker dosing mechanism but at the same time minimize the devices complexity and
the human mechanical interactions.

The Syringe Support by the Foundation Center Louise-Herbert in Canada: At $19.95,
this product is perhaps best noted for its cost effectiveness. However, there is a definite
detriment to its lower price. Its design lacks both audible and tactile indicators of dosing units.
It also relies on a turn screw mechanism to draw the syringe back. This is a disadvantage
because the patient must count, without indication, the number of turns the screw has been
twisted; this may prove especially difficult for clients with limited motor functions.
Furthermore, the device does not have an easy mechanism for mixing; the vial must be
disengaged and then a new one fixed in place every time. Although this is a competitive product
in terms of pricing, it does not meet product expectations in terms of accommodating disabilities,
and is sizably susceptible to error (all information from http://www.nfb.org/vodold/inslmeas.htm, Insulin Measurement Devices).

VI. DESIGN OBSTACLES

Upon discussion of the design of the accessible syringe dosing device, the design team has encountered several questions that are currently unanswered. Some of the questions that are unanswered at this stage are exactly how patients with combinations of disabilities, such as blindness and loss of hearing, will be accommodated to easily use the device. Along with the many questions dealing with client approval and input are questions dealing with the mechanical aspects of the device. Such questions are how to implement a simple motor in which the rotational force of the motor is converted into an axial force on the syringe. From preliminary discussions, the design team has determined that this will be done using a gear system; however, there are still questions regarding this method of implementation. Another design question deals with how to program a microprocessor for the different inputs and outputs from the display module to correctly and accurately control the motor-gear-syringe system. In dealing with the many options that are currently on the market today, choosing the best materials for the device while keeping the weight to a minimum and the overall cost of the device competitive will be challenging. As the design team continues to discuss these and other uncertainties, it is inevitable that additional design obstacles will present themselves.