

## Diaper with Automated Drainage System for Dependent People

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### Abstract

During the life cycle of people, some lose functional autonomy and a capability, which leads to dependency, with little or no mobility, due to physical or psychological factors, and not having sphincter control, some are exposed to frequent use of urine collectors such as diapers or bladder catheter for urination control, which cause inflammation and erosion of the skin by prolonged contact with urine. This work shows the implementation of a prototype diaper designed with reusable fabrics and an integrated device for automated drainage, combining Information and Communication Technology (ICT) tools and electronic components that together achieve a device capable of directing and / or route the urine collected from each urination, to a urine collection bag, its self-control allows minimizing the time of exposure to moisture and avoid over hydration of the skin, which causes severe skin lesions. The purpose of making this project known is for educational and motivational purposes for the areas of knowledge where technologies are applied for the benefit of society.

**Keywords:** reusable cloth; collection bag; catch urine; sphincters

### Introduction

In Mexico, according to the General Population Council, life expectancy is around 75.2 years [1]. During the life cycle, some people lose capabilities and functional autonomy, which leads to being under the care of a third person to perform basic functions, such as care and personal hygiene.

For [2, 3, 4], a person is considered dependent if they have a deficiency that refers to any loss or abnormality of a psychological, physiological or anatomical structure or function; In addition, it exposes a disability that is understood as the restriction or lack (due to an impairment) of the ability to perform an activity in the manner or within the range considered normal for a human being; as well as a handicap that refers to a disadvantageous situation for a specific individual, as a result of a deficiency or disability.

In its World Report on Disability, the WHO (World Health Organization) argues that more than one billion people live worldwide with some form of disability, around 15% of the world population, of which 85 million of the cases are located in Latin America, representing 8.5% of the inhabitants [5]; [6] explain the effects and complications of scenarios such as work.

In the National Survey of Demographic Dynamics 2014, reported by the National Institute of Statistics and Geography (INEGI) of the total population with disabilities, distributed by type of disability in the State of Guerrero out of a total of 3,533,521 inhabitants, 68.8 are known % of the population with disabilities to walk, go up or down using their legs, and 30.3% to move or use their arms or hands [7].

People with disabilities or dependents who have little or no mobility, are regularly exposed to the frequent use of diapers or bladder catheter for sphincter control, in addition to being in charge of third parties for the regular change of the urine collector [8].

In the research carried out, it is proposed that in order to reduce the prolonged time of exposure to urine moisture, a device is built that helps improve sphincter control in dependent people. The initiative is related to people who have difficulty with sphincter control; therefore, they require the use of urine collectors, bladder catheter or disposable diaper. That said, the exposed proposal consists of the design of a device that allows its reuse, drainage and automatic collection of urine by means of a collection bag.

Therefore, the main objective of this project is to design and implement a diaper prototype that prevents prolonged contact with urine in dependent patients due to lack of mobility and thus avoid over hydration of the skin, which allows avoiding skin lesions; all of the above with the support of ICT.

In addition, as specific objectives to be resolved, the selection of materials with characteristics for reuse and impacting in favor of the consumer are considered; In addition, that the savings for the consumer when compared to the existing single-use urine collection products, are low and have a positive impact on the family economy and with an ecological impact by proposing a reduction in products with an environmental impact.

As a result of the present research developed, the most relevant theoretical aspects considered are described below, as well as information that entails a current state of the art.

People who have little or no mobility to control sphincters are exposed to the frequent use of disposable diapers or urine collectors that increase the presence of erosion or inflammation of the skin [9].

Adult humans typically produce about 1.5-2 liters of urine in a 24-hour period. Urine irritates the skin and overhydrates it, making it more vulnerable. It increases the PH (Potential Hydrogen) of the skin's acid mantle and increases the level of friction when wet skin slides over absorbent pads or bedding. There are several elements in urine that have been associated with a greater probability of causing damage to the skin, highlighting the duration of exposure to moisture [10].

Incontinence-associated dermatitis (IAD) according to [11], it is defined as inflammation of the skin on contact with urine or fecal matter in the perineal region or perigenital skin. They are injuries related to health situations, in patients who are generally elderly, with some pathology associated with urinary or fecal incontinence, with the use of absorbent underwear and prolonged bed rest.

The diaper model has evolved over the years, in the 40s only cloth diapers were used, in the 50s a new disposable diaper proposal emerged [12], making a search for modifications and new proposals, patent registration applications were detected, highlighting those considered most relevant based on the research carried out:

The electronic device (Electronic Diaper) receives the signal from the connected detection cables through urine, passes the signal to the controller, which calculates and converts the signal to emit light, indicating that the diaper has been wet and needs to be cleaned. be replaced with a new one. However, it only emits the signal, so if the diaper is not replaced even with the signal emitted, the user will be exposed to prolonged wetting. In addition, it has the characteristic of being a single-use absorbent diaper, so it does not consider the environmental impact [13].

Similarly, [14] highlights the urine detection device with adhesive tape and emitting sensor; In this inventive record, the idea is to apply a special adhesive tape on any type of diaper, compress or underpad normally used in medical centers, hospitals, residences and geriatrics. The strip tape is equipped with two longitudinal, parallel metal conductors, on which it is connected by superimposition to a 90 K $\Omega$  resistor, which is located at one end of the tape, which produces warnings through the LEDs, and transmits data via wireless connection. This proposal is very interesting, however, it repeats the same problem that, if there is no person nearby, even with activated LED warnings, the device could not be replaced and the person would be exposed to moisture for an indefinite period of time.

The proposal made in the research presented in this article aims to address aspects that do not include as a whole the various options located so far in works such as those reviewed in: [15, 16, 17], to highlight part of the previous works reviewed.

Therefore, the context of the research developed to achieve a prototype of a diaper with a drainage device supported by technologies and aimed at dependent people is explained, the use of technological tools applied to a prefabricated diaper with low environmental impact materials is highlighted, and that is carried out with a physical and electronic design with own studies of those involved in the investigation.

Therefore, the physical design has been a meticulous choice between various reusable fabrics with low environmental impact, some of them specially designed to contain the passage of liquids and be an excellent antimicrobial barrier to promote hygiene conditions during use.

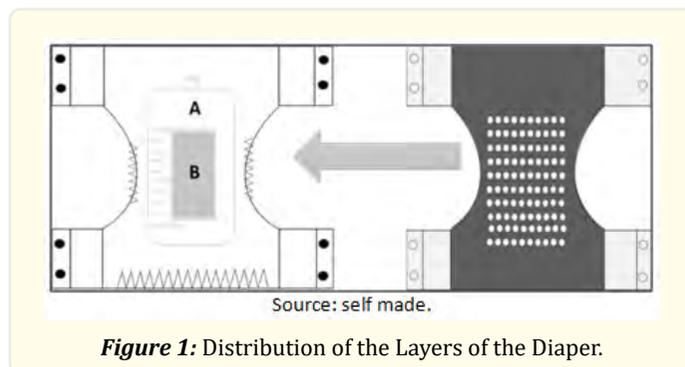
Regarding the electronic design, an interconnected device was taken into account capable of detecting moisture each time a urination occurs, which activates the mechanism to drain the urine, direct it and deposit it in the collection bag.

The prototype developed here constitutes the first diaper with automated drainage, its self-control allows it to start and stop the draining process automatically, which allows minimizing the time of exposure to humidity, it also allows the reuse of the diaper, following the pertinent cleaning measures, for increased durability and optimum performance.

## Materials and Methods

To achieve a functional and comfortable design, an adjustable diaper was modeled that included a network system with electronic components to capture urination, following a layered structure:

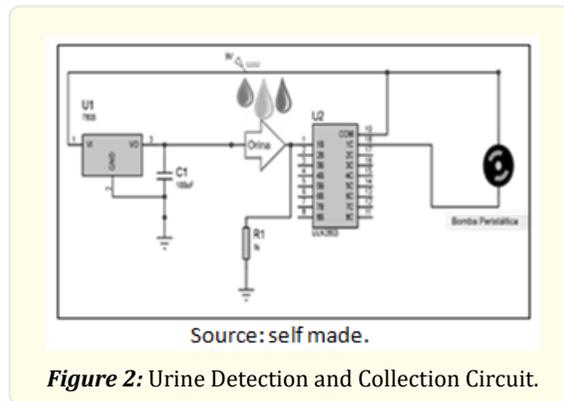
The first layer of the diaper appears to be made up of a waterproof fabric to prevent the passage of liquids, it consists of springs in the legs and waist, side snaps distributed in the 4 corners of the diaper, as can be seen in figure 1, added with a graduated bag urine collector (A), and a surgical silicone mold (B) which allows urination to be captured, in this space the stainless wiring is placed, which will be connected by means of the stored urine, thus obtaining the signal that is sent to the electronic circuit.



**Figure 1:** Distribution of the Layers of the Diaper.

Continuing, the last layer is placed on top, and it is composed of non-woven fabric type SMS (word composed of Spunbond plus Meltblown plus Spunbond) that according to [18] presents resistance to the passage of liquids, microbial resistance, does not accumulate heat or humidity, excellent air permeability; A circular strainer-type cut was made to capture urination and thus filter as quickly as possible.

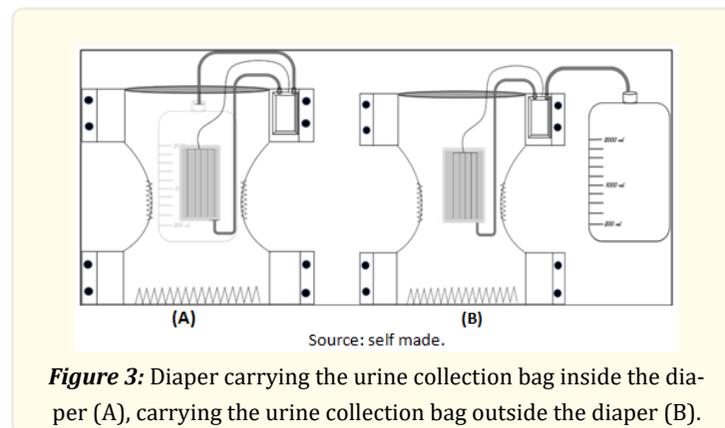
For the construction of the electronic design, an adaptable design proposal is made that consists of electronic components (as shown in figure 2), such as detection wiring arranged in such a way that, when in contact with urine, the signal is activated and is sent to the circuit, driving the pump control to route or direct the urine to a collection bag, this mechanism will automatically drain each urination, thus avoiding prolonged skin exposure to urine moisture. The voltage supply is covered by a 9 Volt rechargeable battery.



Detailing Figure 2, the circuit uses the integrated ULN2803 as a base, which allows interconnecting the urine detection cables with the motor in charge of draining [19].

The complete circuit shown in Figure 2 is constituted inside a casing (Figure 3 upper right part of Figure B) arranged on the side of the diaper, it is also available to be placed in the part of the body that is required.

The functional prototype is shown in figure 3, as the specific distribution of the hoses and the urine collection bag carrying and distributing its capacity inside the diaper (A) or carrying the collection bag outside the diaper (B).



## Results

For the initial tests, urine was replaced by simple water (which contains natural salts), considering that both are conductive liquids, a measure of 400ml of liquid was used and the number of holes in the strainer was varied (from 8x8 to 8x18 with jumps). 2) the previously performed, must specifically comply with the filtering of urine in the most efficient way possible, the times in minutes were recorded, for 6 different amounts of orifices, performing the same test 10 times and the estimated average of drained, it was observed that the time improves if the number of holes is increased, but the maximum number was reached with 8 x 17 that allowed to be carried out, with this it was possible to keep leaving exactly in the lower part of the intimate parts where the urination.

The filtrate of the liquid of the first layer is captured instantly with a filtering time of around 1 to 3 seconds, and on average 1.46 minutes it takes to drain from the Silicone Mold towards the urine collection bag, thus obtaining a considerable minimum time for urine-patient contact. This allows exposure to moisture to be relatively short, thus meeting the goal of preventing skin damage.

## Discussion

As part of the tests related to absorption, it was considered to work with a commercial brand of a disposable diaper in Mexico, comparing the results with the diaper prototype made, where the following results are obtained.

20 minimum and maximum humidity measurements were made, pouring 200ml of water on the disposable diaper (as illustrated in figure 4), the maximum humidity found was 81%; It required approximately 50 to 70 minutes to lower the humidity from the maximum limit to the initial limit and the process is gradual to go down.

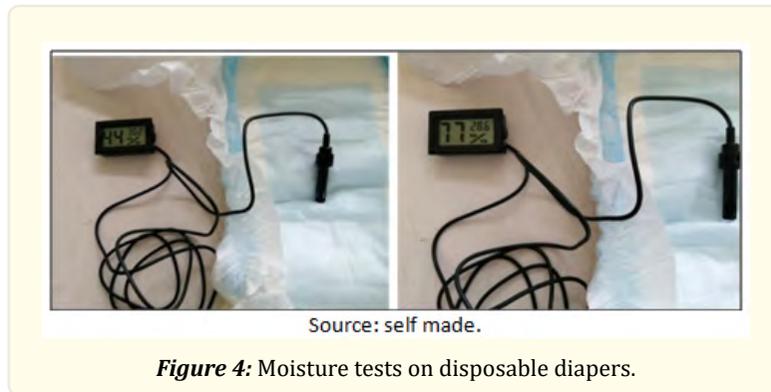
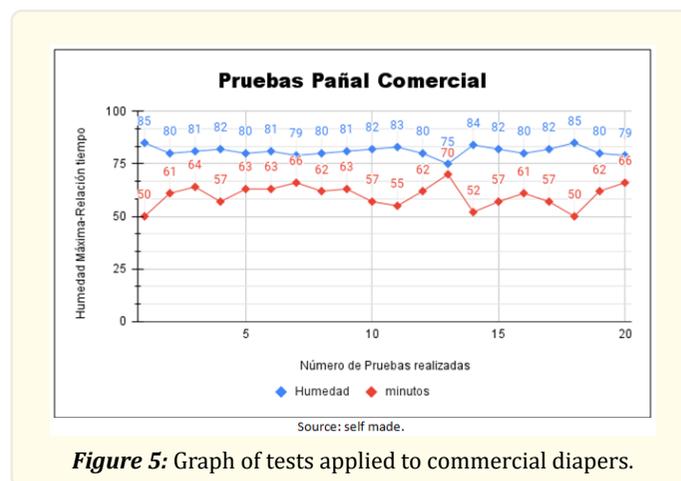
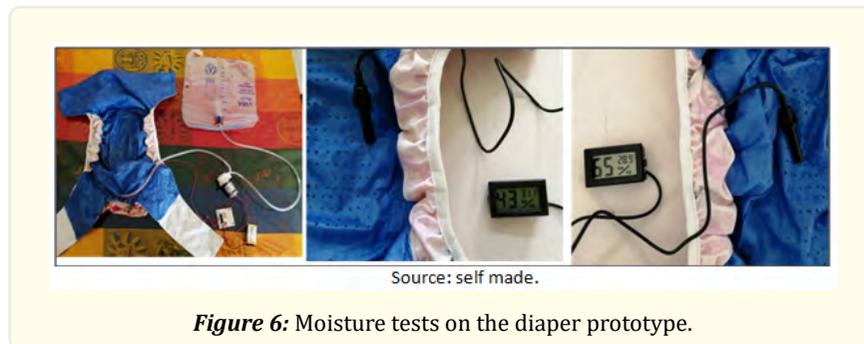


Figure 5 shows the behavior of the tests carried out at the end of twenty repetitions for liquid uptake, in this way the maximum humidity that can be had in the applied commercial product can be averaged.

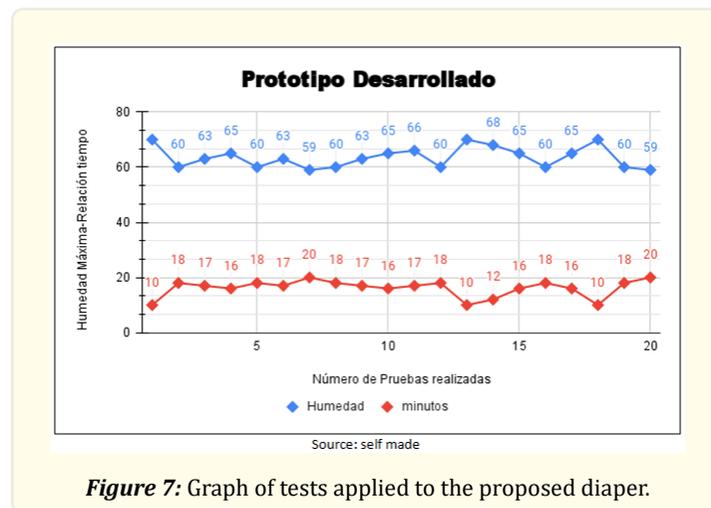


In the same way, the same test is repeated 20 times, with the same amount by pouring 200ml of water on the designed diaper prototype, as illustrated in figure 6.



The maximum humidity found is 70%. It takes approximately 10 to 20 minutes to lower the humidity from the maximum limit to the initial limit. But it takes about 8 minutes to go down from the maximum limit to a medium limit.

In the same way, the behavior of the maximum humidity found in the proposed product can be observed, which can be seen in figure 7 below for its interpretation.



## Conclusion

The proposed diaper prototype compared to the most used urine collector: the disposable diaper, presents a considerable advantage in terms of humidity found, the disposable diaper by gelatinizing the urine prevents it from coming to the surface in liquid form, however, the moisture remains there and is what causes overhydration of the skin and therefore makes it more sensitive to damage and erosion, contrary to the proposed prototype, since when the liquid is drained, the moisture that is stored is minimal and therefore exposure to moisture is greatly reduced.

The diaper prototype is in the validation phase to start the real tests (patient-urine) and capture urination for up to 12 hours, where tests will be carried out to verify humidity, comfort, vibrations, among other possible factors.

The purpose of publicizing this research project in its validation stage is for educational and motivational purposes for the areas of knowledge is to disclose the result of having applied technologies for the benefit of society, in addition, it is worth mentioning that until At the moment, the prototype is in the process of being registered as a patent under the file MX/a/2021/007664 before the Mexican Institute of Industrial Property of the Divisional Directorate of Patents in Mexico, with the name of "Device for the automated drainage of fluids corporal for dependent persons".

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