

Not All Heroes Wear Capes!

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This is how the expiration lock on a medical device used for home blood coagulation testing can be bypassed. By resetting the device's date, expired but still functional test strips were used, saving both time and money.

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Prothrombin time(PT) is the time for blood to start coagulating[1]. International normalized ratio (INR) is calculated from PT by dividing it to a control PT value:

$$\text{INR} = \frac{\text{Patient PT}}{\text{Control PT}}.$$

The control PT value is about 11.0-12.5 seconds. A very high INR (> 5.5) value means that the blood takes very long before coagulation takes place and the patient has the risk of bleeding. Many people with a heart condition are on lifelong anticoagulation with warfarin and they need to monitor and keep their INR value around 2. The test for INR can be done at labs or at home using hand held devices. New research[2] shows that it might be possible to use smartphones to measure INR.

A drop of blood is deposited on the test strip and it is inserted into the device for measurement. The strips and the device are fairly expensive, particularly for developing countries. As of the time of writing this post, the device with 24 strips cost the equivalent of \$500 in my home country. To put that into perspective, it must be noted that it is more than monthly minimum wage.

My father has one of these devices and the strips. He runs the test once or twice a week to adjust his medication. I had a short trip to visit him recently and we attempted to do the test together. However, the device threw an error. We put in a new strip to get the very same error one more time. Even the third one didn't work. They were surprised and upset since they had done the very same test only three days ago with the same device using the strips from the box with no issues. I took a closer look at the box to find out the strips expired literally two days ago. There were 14 of them left; more than half of the box! My parents were very upset for multiple reasons. Most importantly, they needed to get the INR number on that day to

adjust the dosage of the medication. Secondly, there were 14 wasted strips; that is significant amount of money. And finally, it is a 5-hour round trip with the public transportation to get to their pharmacy to buy replacements.

What immediately struck me was the insane accuracy of the expiration of the strips. How did strips themselves know today's date? This requires some more information for the uninitiated. The strips come with a small card that you plug into the device. I think the card has a small memory storing the serial numbers and possibly some parameters associated with the strips. But the card itself is tiny too. How does the card know today's date? It has no internal clock for sure.

I almost instantly figured that the card only stores serial numbers for the strips and the expiration date for them. The device itself compares the stored expiration date against the date today, and refuses to run a test beyond the expiration date. To test my hypothesis, I decided to change the date on the device. I removed one of the batteries which forced a reset on the date. I dialed it back to the beginning of 2022. Put back the same strips that were throwing errors, Lo and behold, it worked like a charm. We went ahead and did the test to read a number very close to the last one (which in turn was very close to the result they got from a clinic a week ago). So, I became a hero for the night, saved the day and a box of strips!

Am I risking my dad's life by reviving to-be-expired strips? I don't think so. First of all, I work for a manufacturing company and have expertise in reliability. There is no way one can predict the expiration date of a device with such accuracy. Note that these strips have a shelf life of multiple years, and they can't be good one day and expire the very next day. It is just a defense mechanism the company put in place to avoid nasty law suits. And furthermore, wasted strips are good for them. You have to go and shell out insane amounts of money to buy more strips while you have perfectly functional "expired" ones at home. But, the strips go bad eventually, don't they? Yes, possibly years after their supposed expiration date.

I reminded my parents that when they buy the new set of strips they needed to make sure the expiration date is far out so that they will consume them all by then. If they fall behind for a few months, we can fool the device to accept the strips while keeping an eye on the measurements like a hawk and comparing them to what they get from the actual lab pretty much every month.

And that's it!

- [1] S. Alvaran Tuazon, "Prothrombin time," 2019. [Online]. Available: <https://emedicine.medscape.com/article/2086058-overview?form=fpf>. [Accessed: 21-Nov-2023]
- [2] J. Chan, K. Michaelson, J. Estergreen, D. Sabath, and S. Gollakota, "Micro-mechanical blood clot testing using smartphones," *Nature Communications*, vol. 13, Feb. 2022, doi: [10.1038/s41467-022-28499-y](https://doi.org/10.1038/s41467-022-28499-y).