**Diabetes, blood sugar, and red wine: a personal study**

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**Diabetes and me**

This is an account of a little research study which I carried out, using myself as the only research subject. I shall describe how I came to do it and some of the practical statistical problems which I encountered.

Around the beginning of 2001, I was told that I had type II diabetes. This was a shock, but not a great surprise. My mother, father, and both my grandmothers had type II diabetes. We do not know about my grandfathers, as both died as young men, one in an accident and one in warfare. Several other members of my family had or now have it.

One of the things my new status as a diabetic brought was a daily measurement of blood glucose. I make this with the aid of a finger prick to raise a drop of blood, which is then put onto a strip of plastic to be read by a little electronic device. Being a statistician, I love data, so I began to save these measurements. I watched as, day by day, the blood glucose fell. With the support of excellent GPs, drugs, exercise, and diet, my blood glucose came under control. Just to give the scale, the initial blood glucose measured by my GP was 24 mmol/litre, my first fasting blood glucose, measured before breakfast, was 19 mmol/litre, my target was less than 7. I continue to measure my fasting glucose every morning. Over time, it fell and eventually reached the magic 7. For several years it remained comfortably below the limit and I stopped recording it, as nothing interesting was happening.

Then several things happened about the same time. The method of measuring glucose changed, from the concentration in blood to the concentration in serum, i.e. in the liquid component of the blood. As glucose is highly soluble, it is nearly all in the liquid. Removing the solid blood cells from the blood and leaving the glucose raised the concentration. The target upper limit was now around 8 mmol/litre.

**HbA1c**

There is a second measurement used to monitor diabetes: glycosylated haemoglobin, or HbA1c. This is measured using a much larger sample of blood, which has to be sent to a lab, so is always done at a clinic, perhaps twice a year. It measures the glucose exposure over several weeks rather than over a few hours. For this reason, it is the measurement doctors prefer to use to monitor diabetes. The second change that happened was that the units of measurement of HbA1c also changed, from a percentage to mmol/litre.

I got quite a shock when my GP told me that my HbA1c was 75; I was expecting about 6.5%. She explained the change in units to me. But there was also a shock, because 75 mmol/litre was a very high value. My GP advised that it should be 59 or less. That was the third change. My glucose was out of control again.

I decided to move to a more rigorous diet. Not only would I avoid all sugar, I would now restrict my carbohydrate intake to one slice of bread per day. No more potatoes for me. I would try harder to avoid beer and white wine, as vehicles for carbohydrate and sugar. When I drank alcohol, I would drink red wine. I also resumed recording of the daily fasting glucose, to monitor the effects. Figure 1 shows them, since 2012. As the graph shows, I was quite successful over the first year, after that it became erratic, with rises and falls and occasional spikes, often coinciding with holidays. My glucose control medication was increased at several points.

**Figure 1 about here**

Figure 1 also shows that the HbA1c rises and falls with the fasting glucose, as we might expect. I thought it would also be interesting to see whether I could predict HbA1c from the fasting glucose. First I tried the average glucose over the preceding 42 days, later switching to the preceding 60 days, which gave a smaller error. Figure 2 shows a plot of the HbA1c against mean fasting glucose, for data up to 16 August 2017. The figure shows the regression line predicting HbA1c and the confidence interval for the prediction, the range of values within which we estimate the actual HbA1c to be.

**Figure 2 about here**

Figure 2 also shows the HbA1c predicted for 16th August, when I had blood taken. I arranged this just before a family holiday, when I was expecting to be plied with food and drink which might increase HbA1c. When I came back, I obtained the measurement from my GP. It was 59 mmol/litre, as predicted by my model. Statistics can be powerful. However, as these data are only for myself, we do not know how well my equation might work for somebody else.

I find this prediction very useful in monitoring my HbA1c, which I cannot measure for myself. I also find the latest version of Figure 1 useful in discussions with my doctor, about diet, exercise, and medication. Indeed, I find my general knowledge as a medical statistician helpful. I told the GP who diagnosed me that I would be his most compliant patient ever. As a medical statistician, I read the research; I knew what could happen if I did not.

**Red wine**

My wife, who likes to keep informed of my sugar level, remarked one day that my blood glucose seemed to be a bit lower on the mornings after I had had a drink. I decided to add my wine drinking to my daily glucose record as a prospective data collection, to test the hypothesis that red wine was associated with reduced blood glucose. As we had not noticed this effect for other alcohol and I knew that it was possible that white wine or beer might increase glucose, I also recorded an “other alcohol” variable. This also included the occasional glass of whisky.

My planned statistical analysis was by the two sample t method, because I knew that my glucose measurements followed an approximately Normal distribution. To examine the effects of alcohol other than red wine, I planned to carry out a multiple regression of glucose on red wine and other alcohol jointly, as I suspected that the effects of the two would be opposite and also because I thought other alcohol consumption would not be independent of red wine, as it would often happen on social occasions.

On the morning after the day that I decided to write this article, March 28th, I had a very high fasting glucose of 9.0 mmol/litre, following a dinner with red wine and sparkling white wine. I had been curious to see how the data were progressing, so I had been monitoring the comparison. This day increased the running P value for my significance test. Of course, as a statistician, I knew that this was wrong, but I had been doing it purely for my own interest. I knew that if anyone was going to take this study seriously, I would need to set a date for formal closing of the data set. Repeatedly carrying out significance tests leads to the risk of invalidating the whole thing by choosing the final date just because the results fit the theory. I chose June 30th, to allow time to prepare an article for the end of the year.

When I came to do the analysis, I had these data from 12th December 2016 to 30th June 2017. Alcohol and glucose were recorded on 192 days, for which I had drunk red wine on the previous day on 99 (52%). This would usually be two or three glasses of wine. Other alcohol was recorded on 19 days (10%).

**Figure 3 about here**

Figure 3 shows a scatter plot of my fasting glucose against red wine consumption. The data appear to follow a Normal distribution with uniform variance quite closely, apart from a few outliers, and the sample is quite large, so a two sample t test was used for the comparison. The analysis ignores the fact that glucose measurements from day to day are related. A high glucose day tends to be followed by another high glucose day, as Figure 1 shows. In statistical terms, there is autocorrelation. This is difficult to deal with and I did not try, so my analysis is only approximate.

There was a difference in mean glucose, red wine minus no red wine, equal to −0.28 mmol/litre (95% CI −0.51 to −0.06, P = 0.01). Thus we have good evidence for a relationship between red wine and glucose, which we estimate to be lower by between 0.06 and 0.51 mmol/litre on average on days after drinking. This is only a small effect, but it appears to be real.

In view of my comments about the importance choosing an end date for data collection, it is interesting to look at the sequential P values, calculated day by day as the data accrued. If there were a genuine difference due to red wine, we would expect the P value to tend to get progressively smaller as data were added. If there were no true difference we might expect it to go up and down in a random way, bearing in mind that each P value is linked to the one before. Figure 4 shows P value against day order. This test was statistically significant when I decided to write this article, on day 87, but around day 140 it ceased to be so. It became significant again before my predetermined analysis point and overall the trend was downwards. I think this illustrates well how repeated significance tests are unstable and a single test can be highly misleading. We should decide what test we are going to do and when before we start. We must not keep adding data and testing again until we get the result we want. In this case, I think that overall the evidence does support the red wine hypothesis.

**Figure 4 about here**

Other alcohol was associated with red wine, being consumed on 14.1% of red wine days and 5.4% of days without red wine. The multiple regression of glucose on red wine and other alcohol produced an estimate effect = −0.31 mmol/litre (95% CI −0.53 to −0.08, P = 0.009) for red wine and +0.26 (95% CI −0.12 to +0.64, P = 0.2) for other alcohol. Hence other alcohol was associated with an increase in blood glucose, although this was not statistically significant.

**Figure 5 about here**

The serial P values for the multiple regression analysis over the follow-up period are shown in Figure 5. Once the effect of red wine became significant, it persisted throughout the remaining follow-up period. Curiously, other alcohol had a significant effect very early on, but this significance disappeared towards the end of the period, suggesting that the apparent effect may be spurious. This again illustrates how misleading repeated significance tests can be. Here I had a test which supported my theory that other alcohol would increase blood glucose, but the evidence crumbled as I continued. On the other hand, my theory is not refuted by the non-significant effect on my analysis date. The data are consistent with an increase of up to 0.64 mmol/litre, with no difference, and with a decrease of up to 0.12 mmol/litre, as shown by the 95% confidence interval. More data in the future may cast further light on this.

This is an observational study, not an experiment. We must be very cautious about inferring cause and effect. For me, drinking red wine is not random. It tends to happen at weekends and when eating out, for example. I would have guessed that eating out would, if anything, increase glucose, but this is pure speculation. We have also noticed that my glucose appears to be higher after I have eaten curry, even though I usually do this without rice or other carbohydrates. This implies no alcohol consumption if I am at home, often a beer if I am out. Details of food were not recorded. All that can be said is there is rather weak evidence of an association between blood glucose and red wine consumption on the previous day, in one person with diabetes.

There have been other studies of red wine and blood glucose, which have all been of longer term exposure and which have had mixed results. I could not find any for daily effects. Recently, Holst 1 and colleagues reported that regular alcohol consumption was reported to decrease the risk of developing type II diabetes, the lowest risk being estimated to occur at 14 drinks/week for men and 9 drinks/week for women. They did not distinguish red wine consumption.

I wondered whether it would be feasible to do a trial to establish whether the short-term red wine effect was causal. In principle, I could randomise myself to drink on some days but not others. However, I think that this would be unlikely to work. I have a social life and I am honestly not that dedicated to this particular search for knowledge. I suspect that I would be even less likely to be able to randomise others to drink or not to drink on given days. Perhaps there is an animal model. Like most nutritional risk factors, red wine and glucose is hard to study.

This study was prospective and appears to demonstrate an association. However, the sample, one person, is rather small. Even if this relationship were causal and not due to associations with other dietary elements, it might be an idiosyncratic reaction. It might be just me. Perhaps the next step would be to get other statistically minded people with type II diabetes, who also like red wine, to replicate it. It would be nice to explore this wihin my own family, to see whether this is just myself or others who share my particular type of diabetes. Type II diabetes is a condition of later life, and most of my diabetic relatives died some time ago, leaving only one. I do not think she drinks much red wine. Perhaps a few *Significance* readers with diabetes might be moved to add to knowledge. It would be interesting to see how this works in Type I diabetes, too.

For myself, I continue to record my blood glucose. I have added other data: the type of other alcohol, the number of drinks, and some information about food consumption and exercise. And, of course, I shall drink red wine as usual. After all, it appears to be rather good for me.

**Acknowledgement**

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**References**

1. Holst C, Becker U, Jørgensen ME, Grønbæk M, Tolstrup JS. Alcohol drinking patterns and risk of diabetes: a cohort study of 70,551 men and women from the general Danish population. *Diabetologia*, online first, accessed 2nd August 2017.

**Figures**



**Figure 1. Fasting glucose (green line) and HbA1c (blue diamonds) from 2012 to 2017**

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**Figure 2. HbA1c against mean blood glucose over previous 60 days, with the value predicted for a blood sample on 16th August 2017**

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**Figure 3. Fasting blood glucose against wine consumption on the previous day, with box and whisker plots**



**Figure 4. P value for the two sample t test on successive days as the sample size increased**

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**Figure 5. P values for multiple regression of glucose on red wine and other alcohol on successive days**