Integrating Biometric Measurements in a Blaise Instrument

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1 Background

There is increasing interest in including biometric measurements in social surveys to identify associations between socio-economic status and health and mortality. NatCen has been conducting surveys that require collection of biometric data for many years, using both nurses and, for some measures, lay interviewers. These measurements include blood pressure, height/weight, ECG, grip strength, waist/hip circumference, lung function, etc. The traditional approach has been to provide interviewers and nurses with the necessary equipment and train them to measure and enter the data in the appropriate input fields in the survey instruments. This method has some serious weaknesses, such as potential keying errors and the user having to split their attention between the laptop, the respondent and the measuring equipment.

The ideal solution is to use equipment that connects directly to the laptop and to populate the data fields in the instrument with the readings. We have achieved this for one biometric measurement, namely full lung function or spirometry. The lung function module in the survey instrument shells out of the data entry program (DEP) to a third party software that reads input parameters, controls the measurement session and returns the resulting data to be stored in the data file.

The benefits of such a method are particularly compelling for spirometry, as the outcome depends on respondent participation and feedback from the nurse. A forced blowing manoeuvre is required which many people find difficult. Reproducible blows are needed so respondent technique is crucial. The software provides information about the quality of each blow which the nurse uses to improve the respondent's technique and to spur them on to blow in a consistent way. The software can calculate predicted values based on respondent characteristics and use these to spur on the blowing in a consistent way.

2 Finding a New Solution

Our longest running survey with biometric measurements, the Health Survey for England, rotates many of these between survey years. The survey of 2010 was due to include lung function measurements of respondents aged 7 and above. This was last done in the 2001 survey. Given the need to replace our existing stock of spirometers, as the model was no longer manufactured or serviced, we had an incentive to explore the market for a better solution.

Our requirements for the equipment are somewhat different from what medical suppliers usually have to satisfy. The normal environment is a clinic or surgery, which is a fixed, stand-alone setup operated by specialist staff. We needed a portable tool that would ideally integrate with the survey instrument and be used by anyone provided with an achievable level of training.

The market research resulted in a shortlist of two suppliers, who were duly invited for demonstration and discussion. The following topics were raised at the meetings:

- Daily calibration or checking calibration
- How to prepare the machine prior to each use
- How to use the machine
- Infection control and other maintenance measures required
- Data transfer, including
    - using data from the interview (age, sex, height, ethnicity) and
    - saving flow-volume curves for each of the three best curves
- Viewing the blows in real time on the nurse's computer to give instant feedback to nurses and participants
- The ability to add children's incentive software, based on the child's predicted values, to be slightly harder than they are doing but only slightly so.
- The ability to use whatever reference values we choose, e.g. the new predictive equations
- The ability to use age-specific criteria, as the American Thoracic Society criteria are inappropriate for children under 11years

Both systems satisfied our requirements. We did, however, find one of them superior for most aspects considered and equal for the remainder. For example, it was easier to use and had fewer and lighter components. It also appeared more open to the software changes we required.

3 The Product

The new high tech spirometer has a number of technical advantages over older spirometer models.

- The actual measurements are technically more accurate.
- It enables quality control in the field, as the machine identifies if a reading is of an acceptable quality and, if not, what problem occurred. This enables the nurse to encourage the participant to produce a better blow.
- It minimises the number of blows required by identifying whether readings are of a satisfactory quality and reproducible.
- Quality control of the field staff and data is also possible. The proportion of participants whose session quality is rated A, B, C, D or F can be assessed in the office. Any feedback and/or additional supervision and training can be provided to improve the quality of the data collected.
- It records a wider range of measurements (e.g. mid-expiratory flow variables MEF_{25-75}, MEF_{25}, MEF_{50}, MEF_{75}, FET, etc) that can be archived for future use by researchers.
- The flow-volume curve for each blow is recorded and can be archived, so the researcher can, for example, evaluate whether readings can be used, even if they have been rejected by the machine's algorithm.

- The spirometer can store data for several hundred readings which can be downloaded to the laptop, thereby preventing data transcription errors.

There are only two kinds of equipment for the nurse to carry. The **spirometer** is very light-weight and connects via a USB port. The respondent blows through a disposable tube, called a **spirette**, thus eliminating the risk of spreading infections. Some other models require sterilisation of the equipment.

After a period of close cooperation with the software developer we had a version of the spirometry software that satisfied our needs. The default behaviour of the spirometry software is to expect the operator to enter the patient characteristics, such as age, sex, height, weight and ethnicity. These are used to calculate the predicted lung function values. We already collect these variables in the survey instrument, so the software was amended to read them from a text file. We were also given an export facility to extract the session data from the spirometry database, both into a text file and a relational database.

The original software was far too open in terms of available options, such as buttons and menus. These may be useful for the specialist operator in a clinic, but confusing to the nurse working in a respondent's home, so all of those identified were locked down.

4 Making It Work with Blaise

We fortunately have some previous experience of launching third party software from within the Blaise data entry program (DEP). One example is a survey instrument that uses a VB DLL to collect life history data and populates the database through the Blaise API. This was presented at the 11th IBUC in Annapolis under the title *Retrospective Data Collection*. Another example is from the 14th IBUC in London, *WebCATI (Part of NatCen's Multimode Approach)*, which demonstrates a method of accessing Blaise IS surveys from a CATI setup.

4.1 The Interface

The requirements for the interface between the DEP and the spirometry software are different from the examples above. Each blowing session generates a vast amount of data, which are stored in a relational database. Some of these are used to construct graphs to illustrate the blows. Only a few variables are transferred to the Blaise database, such as the quality of the blows and the data items the nurses used to key in themselves when using the old equipment. The rest are sent back to the office in a separate file.

The interface needed to perform the following tasks:

- Transfer data items from the survey instrument to the spirometry software
- Launch the software
- Interrogate the spirometry database for the results of the session
- Create a return of data file
- Feed back a selection of the data to the DEP

We decided to use Manipula/Maniplus to develop the interface because we know it very well and Blaise version 4.8 allows you to launch a Manipula procedure from the data entry program (see 'Alien' in the on-line Reference Manual). The file that the spirometry software reads is of a proprietary structure, which caused us some unexpected effort to reproduce.

4.2 The Blaise Data Model

The data exchange in the data model is implemented as export and import parameters in the alien procedure that declares the Maniplus setup. It is always important to consider how the call to an alien

procedure is controlled. For example, whether or not to invoke it every time the user answers a key question and how is it affected by the selective checking mechanism.

The Blaise Reference Manual ends the section about alien procedures with a noteworthy caution:

"**WARNING!**
There are no restrictions for alien procedures and methods. You may develop any method for graphics, complex algorithms, sophisticated sound techniques or other advanced applications. Take notice that DLL and COM alien procedures and methods are executed outside the Blaise system and any malfunction of using them is at your own risk. We strongly advise you to test alien methods and procedures thoroughly before using them."

We took the decision to block the call to the alien procedure as soon as control is returned to the data entry program. It would otherwise keep being triggered by the checking mechanism. This is quite easily done by routing it on a field, the value of which is changed immediately after the procedure call. The way we implemented the routing still allows the nurse to backtrack in the questionnaire and access the alien procedure again. It would, with hindsight, have been better to block this as well. It was, however, routed around in the version we used for the in-office coding and editing.

5 In Production

The success of a survey depends on much more than the quality of the technical solutions. Introducing new protocols and methods requires planning, testing and training. It all had to be put in place within less than six months, from the decision in the summer of 2009 to the start of fieldwork in January 2010 with a dress rehearsal in September. The contract with the supplier included training sessions that enabled us to train our own trainers. We purchased 100 units of software and equipment and trained a corresponding number of nurses. The training sessions could be spread out over the survey year as not all nurses work in all survey months.

5.1 Installing the New Software on Nurse Laptops

Our interviewers and nurses at the time only had dial-up connections for exchanging files with the office, so the new software couldn't be installed remotely in advance of the training. Instead, their laptops were replaced as they arrived at the training session. The replacement laptops had the software pre-installed. All our field laptops are set up through imaging, so it was added to the nurse laptop image. It also meant that we didn't have to go through a lengthy install procedure at the training venue.

5.2 Quality Control

Since the new software feeds back the quality of the blows both to the nurse and in the data file, we had the opportunity to improve the quality of the lung function measurements. We could put systems in place to monitor the nurses' performance to be able to take remedial action if required. The quality measurement was also checked in the in-office coding and editing. As mentioned above, the algorithm used by the software doesn't always reach the correct conclusion. Each case was looked at to verify the given quality value.

We were also checking the calibration data to make sure that the nurses ran the calibration routine at the start of every working day.

5.3 Reconciling the Data

As always when data are collected through different means, we needed to set up a system to reconcile the data sources and make sure they match across the data files. There was less of a risk in this case, where the case ID is passed to the spirometry database. However, the nurses may make mistakes in selecting the wrong person in the household or the wrong case ID for the address.

6 Further Use

The lung function measurement will not be included again in the Health Survey for England (now renamed to Health & Social Care) for some years to come. However, our main continuous survey, Understanding Society, introduced nurse visits including spirometry in 2010. This survey will continue until the middle of 2012. One complication is that this survey covers both England/Wales and Scotland. The Scottish nurses were never converted to the new spirometry method, so the instrument has to route the lung function module on the country in which the interview takes place.