Safety in Mines Research Advisory Committee

Final Report

Development of percentile charts for semi-quantitative tracking of lung functions over time in the South African mining industry

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Executive Summary

HEALTH 610, entitled “Development of lung function reference tables suitable for use in the South African mining industry”, made far-reaching recommendations pertinent to the practice of spirometric surveillance in SA mines. It recommended inter alia that the optimally valid reference equations it identified be used and be operationally implemented. Health 805 was envisaged as a first step towards achieving better spirometric practice in the mining industry.

The principal aim was the development of percentile charts for semi-quantitative tracking of lung functions over time. It was intended to optimise medical surveillance by graphing successive spirometric measurements. Optimisation would take place in two ways: maximal use of existing historical lung function data for a particular worker, and early identification of lung function loss by examination of the graphical trajectory over time. Three innovative computer-based products were developed for use in small (tens of workers), medium (hundreds of workers) and large (thousands of workers) mines, respectively. SpiroCharter was developed for small mines for hardcopy use, although generated by computer. The other products are computer-based: SpiroTracker for medium mines was developed in Microsoft Excel, and SpiroAccess for large mines is under development in Microsoft Access.

Development methods for the products are outlined, including discussion of iterative methods, development of algorithms for calculating expected values, and change in these values. The utility of the underlying equations and algorithms was examined both conceptually and operationally. The products were piloted in appropriate mining facilities across the country. The products are then illustrated, and are also attached to this report in CD-ROM format.

Intellectual property considerations are yet to be fully sorted out. SpiroCharter is easily copyrighted. SpiroTracker has proved impossible to protect due to the nature of the Excel program. SpiroAccess is still under development and the programming requires finalisation as well as copy protection, which is feasible for Access programs.

The project took an unexpected direction in that what was originally intended as a chart-based tracking system developed into a multi-level computer-based set of products. This developmental work, which included piloting and iterative feedback from potential end-users took up most of the time allotted. However, the main aim of the project has been achieved with the production of SpiroCharter, which is available for immediate use and is submitted in both hardcopy and electronic format in this report. Subject to intellectual property concerns, SpiroTracker is similarly available, while SpiroAccess requires some additional development.

What remains to be done includes marketing of the products and training in product use within the mining industry.

It is hoped that these products will contribute towards an improved surveillance culture on the mines. It is intended that these products be accessible and affordable to operate. Improved surveillance in the final analysis will depend on the will of mine management to engage in meaningful and effective monitoring of occupational hazards and the health of mineworkers. Specifically, this will depend on making full use of all available occupational hygiene and medical data.

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1. Introduction

HEALTH 610, entitled "Development of lung function reference tables suitable for use in the South African mining industry", made far-reaching recommendations pertinent to the practice of spirometric surveillance in SA mines.

It recommended that:

- the optimally valid reference equations identified by the HEALTH 610 report be used and that spirometric measurement and data capturing equipment be programmed accordingly

- lower limits of normality be based on statistical considerations rather than a fixed percentage of predicted values

- attention be paid to the quality of spirometric measurements

- additional crucial data such as smoking, occupation, past tuberculosis and radiological silicosis be gathered at the time of spirometric measurement

- peak expiratory flow rates no longer be used

- the findings be adopted by various key stakeholders, like MOHAC, MMOA, SASOM, and SATS.

Furthermore in the course of HEALTH 610 as reflected in Appendix 3, much reflection took place on appropriate spirometric surveillance, and in particular surveillance of longitudinal change in spirometric parameters over time. Explicit recommendations were made for further research which could inform longitudinal tracking of lung function for individual miners across time, potentially allowing the most sensitive early detection of dust-induced respiratory health problems at a stage before permanent damage is done, as well as obtaining more accurate measures of longitudinal change by using individuals as their own controls with known baseline values. The latter also would potentially allow for the specific attribution of lung function loss to dust and other causes of respiratory ill health, with significant implications for both prevention practices and compensation processes.

Specifically, the recommendations included as future research needs, as contained in Appendix 2 of HEALTH 610:

Stage 1 – a cross-sectional study of exposed miners to investigate dose-response relationships with dust and silica

Stage 2 – a longitudinal study of high and low exposed miners to determine if it was possible to distinguish between their adaptive distributions (i.e. their distributions conditional on their previous spirometric measurements)

Stage 3 – the establishment of a cohort of unexposed workers to determine unexposed adaptive reference ranges. The value of this stage, if completed, would be immense, as the component risks to lung health would be quantifiable.

It was not possible immediately after HEALTH 610 to address all of these research recommendations. Accordingly a more modest endeavour ensued which culminated in

HEALTH 805. This project aimed to pursue a limited number of the above recommendations, as part of an ongoing research thrust to effect the findings of HEALTH 610.

The principal aim was the development of percentile charts for semi-quantitative tracking of lung functions over time. Unpacking this, many of the recommendations of HEALTH 610 were taken forward, despite the limited scope of this project. These were:

- to develop an explicit statistical basis for judgement of the degree of change and abnormality
- to track change over time using cross-sectional data, as an interim measure in the absence of true longitudinal data for change in lung function.
- to examine and use the appropriate cross-sectional reference equations
- to work with appropriate outcome measurements, namely FEV_1 and FVC

It was noted in HEALTH 610 that lung function testing is used extensively in the mining industry for baseline, medical surveillance and compensation purposes. Despite the abundance of lung function data, there appears to be under-utilisation of existing data for individual miners. Typically, data from the current test is compared against reference values programmed into the computer or spirometer without any reference being made to client's previous lung function tests. Information that is potentially available from all the data collected over time is wasted.

It was also noted that there is ongoing uncertainty about choice of reference equations, which can only ultimately be resolved by longitudinal monitoring, in which each employee is used as their own control in evaluating change in lung function. In the interim, it was decided to use cross-sectional equations for longitudinal purposes in the form of percentile charts on which miners' lung functions over time can be recorded. This potentially provides an accessible method for recording and reviewing change in these functions over time with ongoing exposure to respiratory hazards, and will consequently facilitate the early detection of respiratory abnormality. Such emphasis on prior test results will necessitate their use. It is envisaged that this will benefit both miners and the employers who can take early preventative action when abnormal trends are detected – in both individuals and groups.

1.1 Research problem statement

The purpose of this project was to contribute towards the implementation of the findings, specifically of the research recommendations, of HEALTH 610.

Existing surveillance systems for lung function testing on the mines do not use the optimally appropriate prediction equations. Neither do they encourage the utilisation of all available surveillance data from past examinations collected during their working life. Specifically, data from past periodic respiratory surveillance examinations are not factored into the interpretation of the current lung function results. Instead, current results are interpreted in terms of their relationship to the 80% cut off level based on the predicted value produced by software built into the spirometer. This project explores the belief that longitudinal tracking systems are more efficient in interpreting the lung function results produced at any one time, as they produce an idea of an individual's expected lung function trajectory. Additionally, the sensitivity and specificity of test results at one time engender substantial numbers of false positives and negatives.

1.2 Objectives and aims of this study

The principal objective was the development of percentile charts for semi-quantitative tracking of lung functions over time, and also to develop a manual for using percentile charts in electronic and hardcopy format. Suitable products for use in small, medium and large mines would be developed iteratively.

2. Methods and Results

2.1 Conceptualisation

There were 4 crucial steps in the conceptualisation of HEALTH 805:
Step 1 – the realisation that the percentile lines ran parallel
This meant that user-friendly charts could be produced.
Step 2 – the realisation that the percentile lines could be displayed using Excel
This meant that there were accessible tools to explore the equations.
Step 3 – the realisation that the equations could be combined
This meant that the products would be greatly simplified.
Step 4 – the realisation that the products could be entirely computer based
This meant that there would be accuracy and uniformity across the envisaged products

2.2. Generating algorithms based on HEALTH 610 optimal equations

Paper and pencil, Stata and Excel were used to explore the equations and the options possible, in an iterative and augmentative process between the researchers.

Percentile charts and curves such as those published by Dockery et al were found to be user un-friendly, were difficult to explain, and would not be understood by the majority of users. This was mainly because the vertical axis units were volume/height^2, which are non-intuitive. The percentile lines were also curved and slightly convergent. In the course of our explorations we discovered that in contrast to Dockery, the prediction equations allowed the percentile lines to run (straight and) parallel. In addition, they displayed the data in immediately understandable form, with pulmonary function in millilitres on the vertical axis and time along the horizontal axis.

Following this development, Excel spreadsheets were generated using functions that calculated the percentiles.

Feasible ways of presenting the use of the predictive equations in a mine clinic setting were explored initially. Because there were 8 equations (white/black; male/female; FEV1/FVC) identified by HEALTH 610, it could become confusing and it was easy to choose the incorrect one for use in a particular situation. Therefore, in order to facilitate end-users choosing the correct equation, a single combined equation that would represent all groups was derived, for both FEV1 and FVC. The equations are derived from the optimal equations for the different groups identified by HEALTH 610. They are both of the same form.

The equation for FEV1 is:

FEV1 = (-2.492+1.957*"Race"-(0.029-0.002*"Race")*Age+(0.04301-0.01401*"Race")*Height)-Sex*(0.112+1.223*"Race"+(-0.004+0.005*"Race")*Age-(-0.00348+0.00848*"Race")*Height).

The equation for FVC is:

FVC = (-4.345+1.265*"Race"-(0.025-0.001*"Race")* Age +(0.05757-0.00957*"Race")*Height)-Sex*(-1.458+1.418*"Race"+(0.001-0.002*"Race")* Age -(-0.01331+0.01031*"Race")*Height)

"Race" and Sex will take on respective values of 1 or 0 if black or white and female or male, and Height is height in centimetres and Age is age in years. When programmed into an Excel spreadsheet, the computer can calculate the appropriate reference values. The user simply identifies the skin-colour and sex, and the computer chooses the appropriate prediction equations to use. The appropriate standard deviation is similarly identified by computer algorithm, which also then calculates the percentiles. Using the computer algorithms related to these equations minimises human error.

These 2 single combined equations were tested against the 8 group-specific equations, and produce the same results as the original applicable group-specific equations.

The user-friendly Excel spreadsheet was further developed to allow the easy plotting of serial values for lung function parameters, so that individuals' values can be tracked over time. Identification of abnormalities (e.g. FEV1%predicted < 80%) is also done by computer algorithm.

2.3. Exploring the utility of the combined equation

Exploration of the behaviour of the generated percentiles in comparison with the actual expressed as a ratio of predicted values generated from the same equations was the first item to be explored. The question asked was whether the percentiles or percent-of-predicted methods differed in their ability to track modelled changes in the lung health of individual miners. Specifically, relative and absolute drops in lung function were examined in relation to their effect on the change parameter

Tables 1.1 and 1.2 below were used to explore the behaviour of two statistical indices for either a relative (10%) or and absolute (200ml) drop in FEV1. The columns are labelled A – H. Column A is the starting point, and Column B the end point, in FEV1, after the loss has occurred. Column C contains the predicted FEV1 for a 41 year old black male who is 180 cm tall. Columns D and E respectively show the Actual/Predicted FEV1 and the percentile they fall on, for the values in the preceding columns. If the Actual would equal the Predicted, the value for A/P% would be 100%, and the percentile value would be 50. Columns F, G and H show the loss expressed as an absolute loss, as Actual/Predicted FEV1 loss and as the percentile loss respectively.

The tables show that the penultimate column (Actual/Predicted FEV1 loss) reflects losses much more accurately than does the last column (percentile loss). The following paragraph expresses this finding in more detail.

When the percentiles and percent-of-predicted were plotted for either a relative (proportionate) drop or an absolute (fixed) drop, the percent-of-predicted was found for both relative and absolute declines to be a much more constant reflection of the change, across a wide range of starting points of lung function. A fixed percentage-of-predicted change has a similar meaning across a range of initial values, while a fixed percentile change has a very different meaning depending where the reading is in the distribution. It is greater in the middle of the distribution, where the percentiles are bunched as opposed to being lesser, with a range to nought, in the tails of the distribution, where the percentiles are further apart. The same degree of change will, as is shown in the table, be larger or smaller depending on the starting percentile. The percentage-of-predicted method is therefore much more robust in tracking change than percentiles. The percentage-of-predicted method of quantifying change seems preferable. This finding was used to inform the further development of the project's products.

Table 2.1 shows what happens to the actual/predicted% and percentile for a relative loss of 10% across a range of starting points. Please note the wide variations in the last column.

Table 2.1 – Modelling a relative (proportionate) drop in Lung function (FEV_1) for a 41 year old, using the Louw equation

A	B	C	D	E	F	G	H
FEV_1 Actual (A) Initial	FEV_1 Actual (A) Less 10%	FEV_1 Predicted (P)	A/P%	FEV_1 Percentile	Loss in millilitres	Loss as A/P%	Loss in percentiles
4200		3578	117	91			
	3780	3578	106	67	420	12	24
4100		3578	115	87			
	3690	3578	103	60	410	11	28
4000		3578	112	82			
	3600	3578	101	52	400	11	30
3900		3578	109	76			
	3510	3578	98	44	390	11	32
3800		3578	106	69			
	3420	3578	96	37	380	11	32
3700		3578	103	60			
	3330	3578	93	29	370	10	31
3600		3578	101	52			
	3240	3578	91	23	360	10	29
3500		3578	98	43			
	3150	3578	88	18	350	10	26
3400		3578	95	35			
	3060	3578	86	13	340	10	22
3300		3578	92	27			
	2970	3578	83	9	330	9	18
3200		3578	89	21			
	2880	3578	80	6	320	9	14
3100		3578	87	15			
	2790	3578	78	4	310	9	11
3000		3578	84	10			
	2700	3578	75	3	300	8	8
2900		3578	81	7			
	2610	3578	73	2	290	8	5
2800		3578	78	5			
	2520	3578	70	1	280	8	3
2700		3578	75	3			
	2430	3578	68	1	270	8	2
2600		3578	73	2			
	2340	3578	65	0	260	7	1
2500		3578	70	1			
	2250	3578	63	0	250	7	1
2400		3578	67	1			
	2160	3578	60	0	240	7	0

Table 2.2 shows what happens to the actual/predicted% and percentile for an absolute loss of 200 ml across a range of starting points. Please note the wide variations in the last column.

TABLE 2.2 – Modelling a absolute (fixed) drop in Lung function (FEV_1) for a 41 year old, using the Louw equation

A FEV_1 Actual (A) Initial	B FEV_1 Actual (A) End	C FEV_1 Predicted (P)	D A/P%	E FEV_1 Percentile	F Loss in millilitres	G Loss as A/P%	H Loss in percentiles
4200	4200	3578	117	91			
		3578	112	82	200	6	9
4100	4100	3578	115	87			
		3578	109	76	200	6	11
4000	4000	3578	112	82			
		3578	106	69	200	6	14
3900	3900	3578	109	76			
		3578	103	60	200	6	15
3800	3800	3578	106	69			
		3578	101	52	200	6	17
3700	3700	3578	103	60			
		3578	98	43	200	6	17
3600	3600	3578	101	52			
		3578	95	35	200	6	17
3500	3500	3578	98	43			
		3578	92	27	200	6	16
3400	3400	3578	95	35			
		3578	89	21	200	6	14
3300	3300	3578	92	27			
		3578	87	15	200	6	12
3200	3200	3578	89	21			
		3578	84	10	200	6	10
3100	3100	3578	87	15			
		3578	81	7	200	6	8
3000	3000	3578	84	10			
		3578	78	5	200	6	6
2900	2900	3578	81	7			
		3578	75	3	200	6	4
2800	2800	3578	78	5			
		3578	73	2	200	6	3
2700	2700	3578	75	3			
		3578	70	1	200	6	2
2600	2600	3578	73	2			
		3578	67	1	200	6	1
2500	2500	3578	70	1			
		3578	64	0	200	6	1
2400	2400	3578	67	1			
		3578	61	0	200	6	0

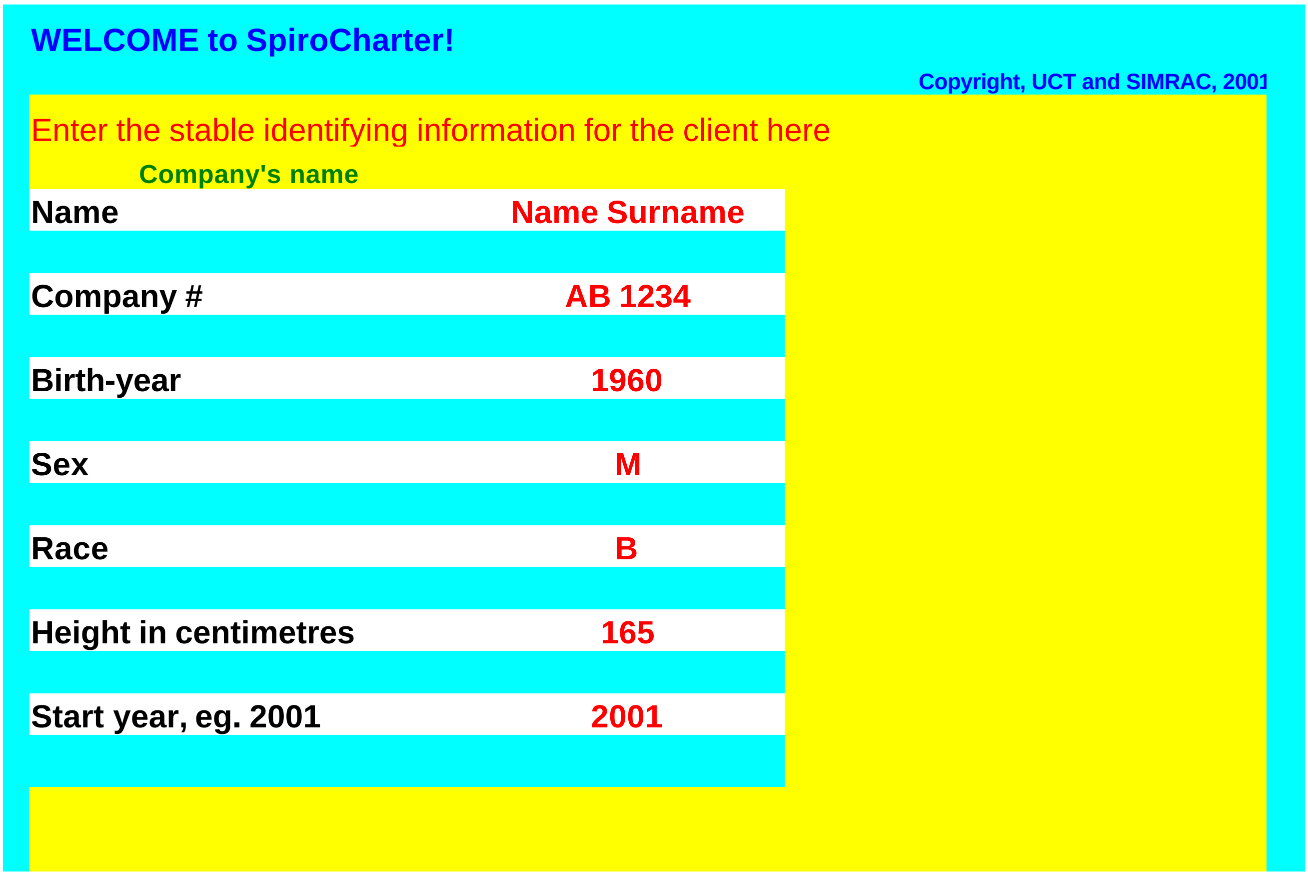
2.4. Generating the products

We conceptualised three products for use in small, medium and large mines. For ease of use and particularly ease of transition between the three products (hardcopy and the computer-based options), it was decided that all the products should look as similar as possible and that they should be based on the same computer programme. The three products came to known as SpiroCharter, SpiroTracker and SpiroAccess.

2.4.1 SpiroCharter – Hardcopy Chart option

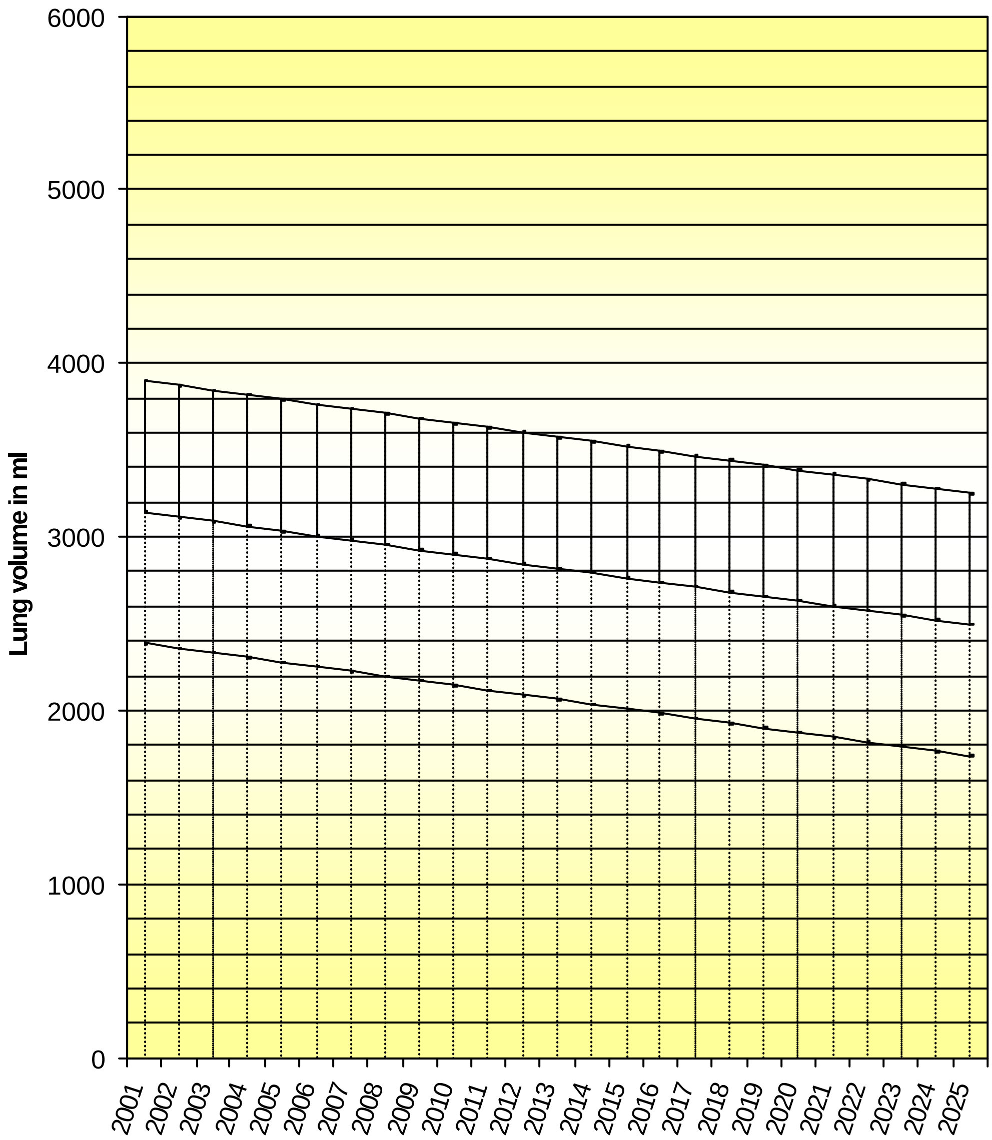
The first product was aimed at being a hardcopy chart option for use in small mines with tens of workers where there was no computer available to the occupational health staff, but where occasional access could be had to a computer printing facility, typically in the administrative section of the mine.

Figure 2.1: SpiroCharter Identity Screen on the computer



The chart of SpiroCharter is shown below. The colours are customisable. The position of the percentile lines will change according to the characteristics of the individual for whom the chart is generated.

Figure 2.2: SpiroCharter Hardcopy Chart



The main site for piloting SpiroCharter was the Tygerberg Quarry. It has some 50 workers, a dedicated part-time occupational health service, but no dedicated computer on site. This made it the ideal place to pilot the SpiroCharter product. The administrative section printed out charts for each worker, having been supplied with their name, age, gender, and height by the occupational heath nurse. The product was piloted for a period of 2 months.

The product was also discussed with the Billiton group in Witbank.

Results of the pilot process for SpiroCharter:

1. The FEV1 and FVC values in the initial (prototype) SpiroCharter had to be plotted in the space between two vertical lines. The occupational heath sister and doctor preferred to plot

the values on a line, as is done with temperature and other charting in hospitals. This change was effected to SpiroCharter.

2. The initial instructions were that FEV1 should be plotted in red and FVC in blue – as is the case in the SpiroTracker version. The nurse found it better to plot the FVC in green. This may be an idiosyncratic finding.

3. The initial FEV1 percentile lines, namely the 95th, 50th, and 5th percentile lines were plotted by the computer with dots at each year. These dots were deemed confusing, and were subsequently removed - the percentile lines now carry no dots.

4. It is moot whether the lower plotted percentile line should be the 5th percentile or the 10th percentile, as is found in the SpiroTracker version. The reason for the 10th percentile being used in SpiroTracker is that one would like to be given the opportunity of intervention before the FEV1 became clearly abnormal, as would be the case with the 5th percentile line.

5. The occupational health doctors at the Billiton group in Witbank would have preferred the SpiroCharter to the SpiroTracker for their purposes. This was because SpiroTracker was perceived to be too labour-intensive for their large numbers of clients. This paradoxical finding was due to the fact that the SpiroTracker is a separate program that does not link to the clients' computer system, nor to their spirometers. The optimal solution would have been the SpiroAccess product, which had not been developed at the time.

SpiroCharter was interactively and iteratively improved to its current final and usable form. We note that SpiroCharter will be the most viable option for most mines, because of their small size. The median number of employees at the approximately 530 mines registered with DME is close to 30 [DME data – personal communication with DME].

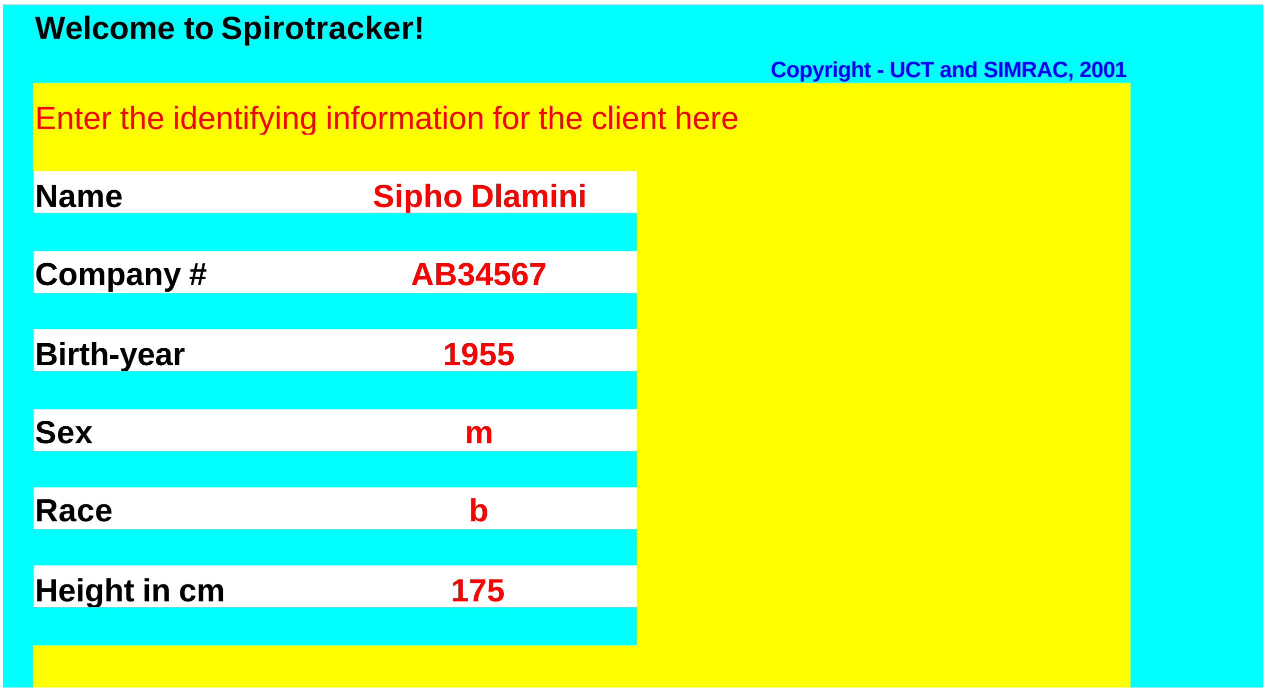
It should be noted that with both SpiroCharter and SpiroTracker, the time intervals between routine tests should ideally be at least 12 months. However, the inter-test variability of 3% accepted by the ATS is in most cases far in excess of the year-on-year average decrease. With a year-on-year decrease of the order of 30ml, the timing of the test within the year (early or late in the year) and the timing of the subsequent tests thus assume less significance.

2.4.2 SpiroTracker

The second product was aimed at use in medium-sized mines with hundreds of workers where there was a full-time occupational health service and one or more computers available.

The SpiroTracker product has 3 screens that are seen by the end-user. Here is the first screen, called the Identity screen. It allows inputs that identify the client a. to the health provider and b. to the computer algorithm.

Figure 2.3: SpiroTracker Identity Screen



The second screen of SpiroTracker is the Entry screen, where the results of the spirometry are entered. It is shown below, and makes algorithmic judgements based on the input values. The "Action" rows state whether the cross-sectional values are normal: "OK", approaching abnormality: "Act", or clearly abnormal: "Act, Refer". The yellow section at the bottom is still under development, and works as a longitudinal tracking device to utilise all the information available for a particular individual.

Figure 2.4: SpiroTracker Entry Screen

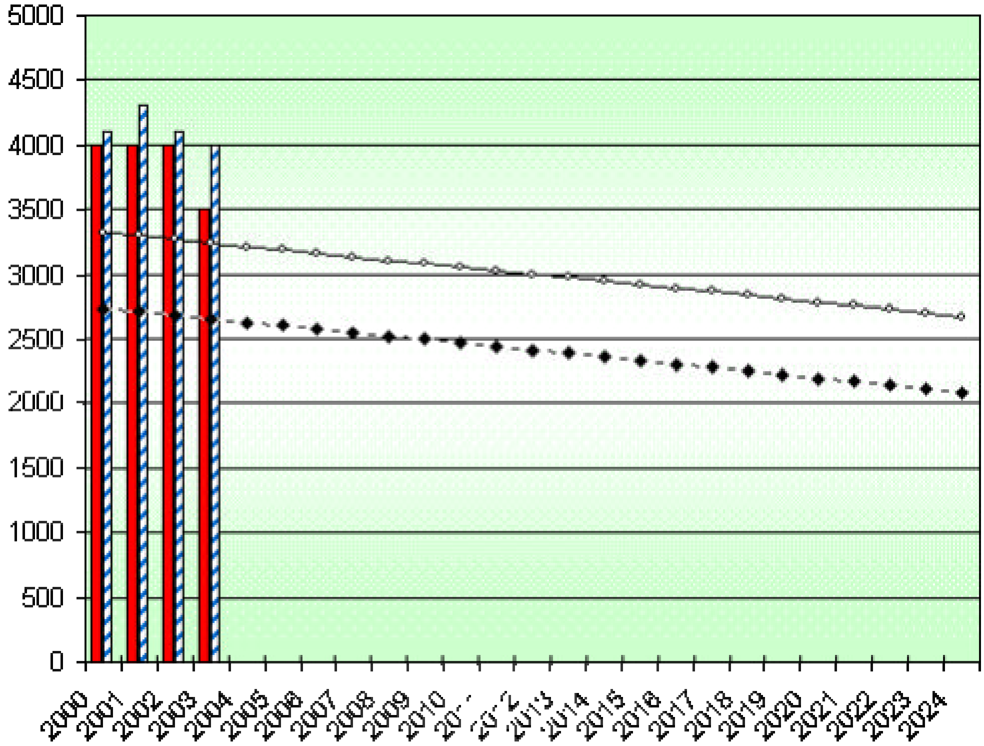
	Entry and decision page				
1	Enter Year	2000	2001	2002	2003
2	Enter FEV1 in millilitres	4000	4000	4000	3500
3	Enter FVC in millilitres	4100	4300	4100	4000
*					
	Predicted FEV1	3325	3298	3271	3244
	Percentage of predicted FEV1	120%	121%	122%	108%
	FEV1 Percentile	93	94	94	71
*	Action:	OK	OK	OK	OK
	Predicted FVC	4240	4216	4192	4168
	Percentage of predicted FVC	97%	102%	98%	96%
	FVC Percentile	40	56	43	38
*	Action:	OK	OK	OK	OK
	Measured FEV1/FVC %	98%	93%	98%	88%
	Predicted FEV1/FVC %	78%	78%	78%	78%
*	Action:	OK	OK	OK	OK
	Average annual FEV1 loss %	Best FEV1	Best FEV1	Best FEV1	13%
	Average annual FEV1 ml loss	Best FEV1	Best FEV1	Best FEV1	500
	Cumulative loss in ml	Best FEV1	Best FEV1	Best FEV1	500
	Comment				Hi loss

The third user-screen is the Chart. It looks somewhat like that of SpiroCharter, except that the computer has drawn the vertical bars - when the values were input on the Entry screen. This screen can be printed out as a stand-alone record.

Figure 2.5: SpiroTracker Electronic Chart Screen, which may also be printed

Name	**Sipho Dlamini**
Company number	**AB34567**

Birth year **1955**
Height **175** **Print date** **13-May-2002**



Note: If the FEV1 falls to below the Action Line, take action!
It is a warning of possible accelerated loss

Red vertical bars = patient's measured FEV1
Blue striped vertical bars = patient's measured FVC
Upper line with circles = predicted FEV1 = 50th centile
Lower line with diamonds = ACTION LINE = 10th centile of FEV1

As can be seen, SpiroTracker is bold and attractive in presentation.

SpiroTracker was piloted at Kimberley Diamond Mines, Koffiefontein Diamond Mines, and the Manganese Mines in the Hotazel area. These mines all have full-time occupational health services, plus at least 1 computer on site. The number of spirograms performed weekly at these workplace clinics rarely exceeds 50. The product was handed over to the occupational health services of each of the participating mines during a personal visit by the project coordinator. It took between one and two hours of one-on-one discussion to explain the workings of the SpiroTracker programme to the occupational health practitioners, who respectively comprised a nurse, an occupational hygienist with computer skills, and an occupational health doctor at each of the participating mines mentioned above. Follow-ups were conducted between one and three months later to ascertain the utility and appropriateness of the product.

Findings of the pilot study included:

1. Users were enthusiastic and impressed with the functionality of the product. At each site where it was demonstrated, it immediately identified a number of "false positives", or clients whose spirograms were identified by the spirometric software as abnormal, but were normal according to SpiroTracker's algorithms because it used the Louw equation rather than the Quanjer ECCS equation (which seems to be universally programmed into spirometric software). False positives lead to loss of productivity for both production and occupational health staff.

2. Difficulties experienced included the need for a separate file for each client, and the fact that the values had to be punched in physically because of the absence of an electronic data link. These features are intrinsic in Excel, and cannot be modified. It seems that once the number of spirometric clients exceeds 15 - 20 daily, keeping up with the workload of punching and saving files becomes difficult. Another difficulty is the inability of the Excel spreadsheet to be made tamper- and mistake-proof. Additionally, intellectual property concerns apply (to both SpiroCharter and SpiroTracker).

Iterative consultations with local experts also took place, in order to get their clinical impression of what magnitude of year-on-year changes could be deemed significant. Based on this work, a function was added to SpiroTracker, which allows for longitudinal tracking. This is based on an algorithm for early detection of abnormal loss. It was developed and refined, and now has the ability to identify high or accelerated losses in lung function where an algorithm (e.g. FEV1%predicted < 80%) based on successive cross-sectional values would not identify anything amiss. It does however need to be field tested, as we do not know the prevalence of false positives here. This work is ongoing.

A clinical diagnostic algorithm eg. “Mild obstruction, no restriction” is in the process of development, but this has not yet been incorporated into the product, as it does not yet match the quality of the other aspects of the products, and is not yet operationally ready for incorporation into either SpiroTracker or SpiroAccess.

2.4.3 SpiroAccess – SpiroTracker in a relational database

This third product was aimed at use in large mines with thousands of workers where there was a full-time occupational health service and the spirometry capture system is computerised. The idea of producing this product arose as a consequence of feedback from the presentation of an interim quarterly report to SIMPROSS.

The SpiroAccess product has at least 4 screens, and all screens are customisable. Here is the first screen, called the Identity screen. It allows inputs that identify the client a. to the health provider and b. to the computer algorithm.

Figure 2.6: SpiroAccess Front Screen

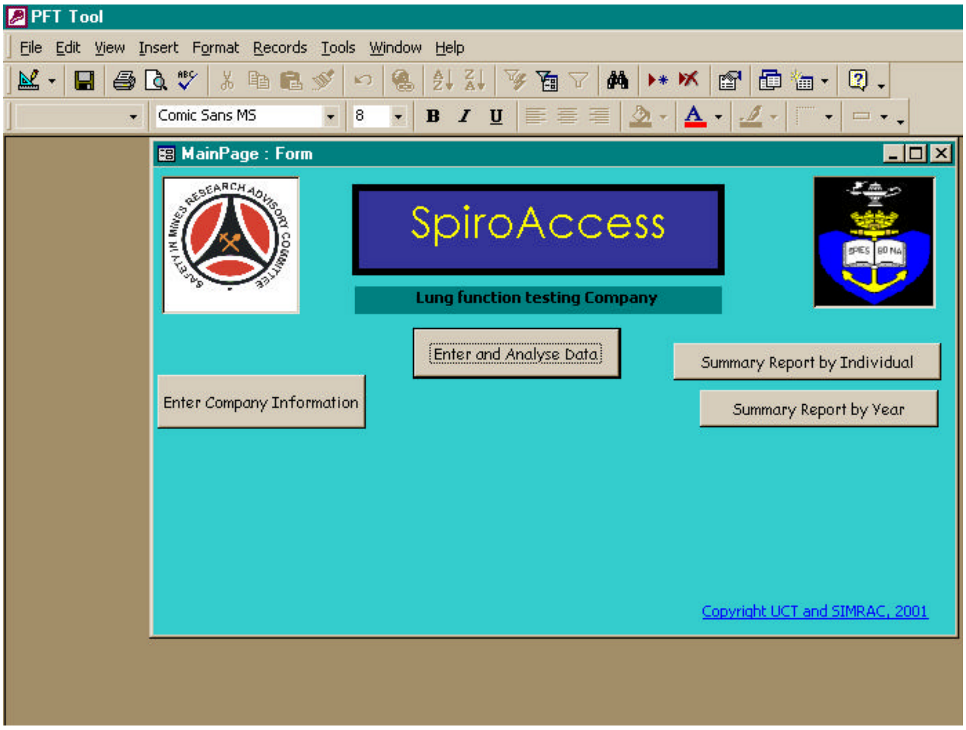


Figure 2.7: SpiroAccess Identity Screen

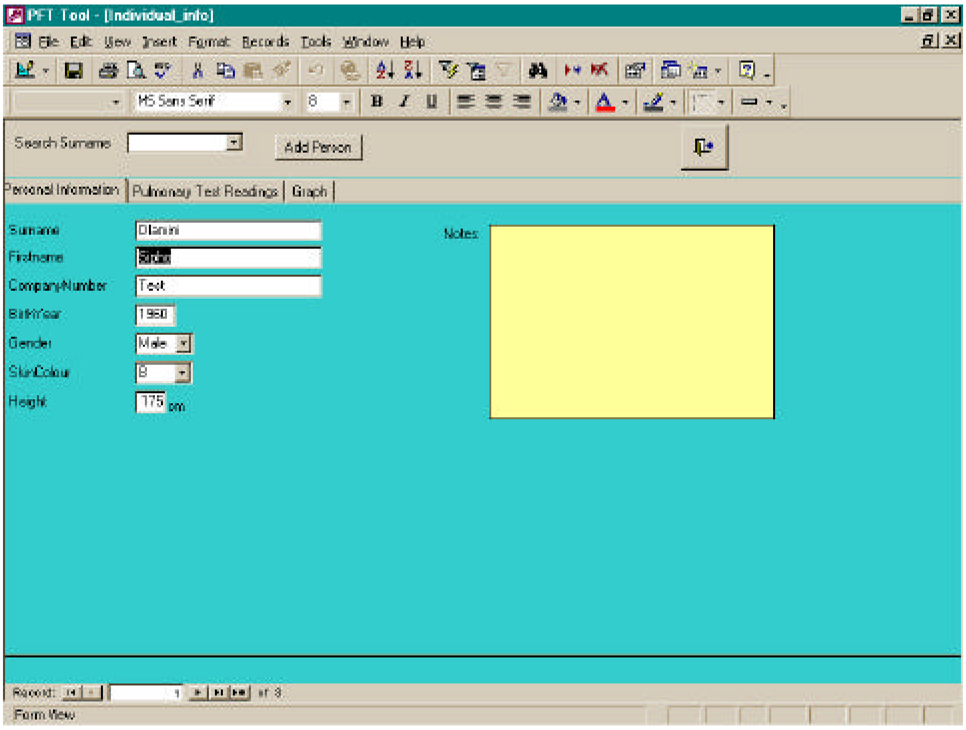


Figure 2.8: SpiroAccess Entry Screen

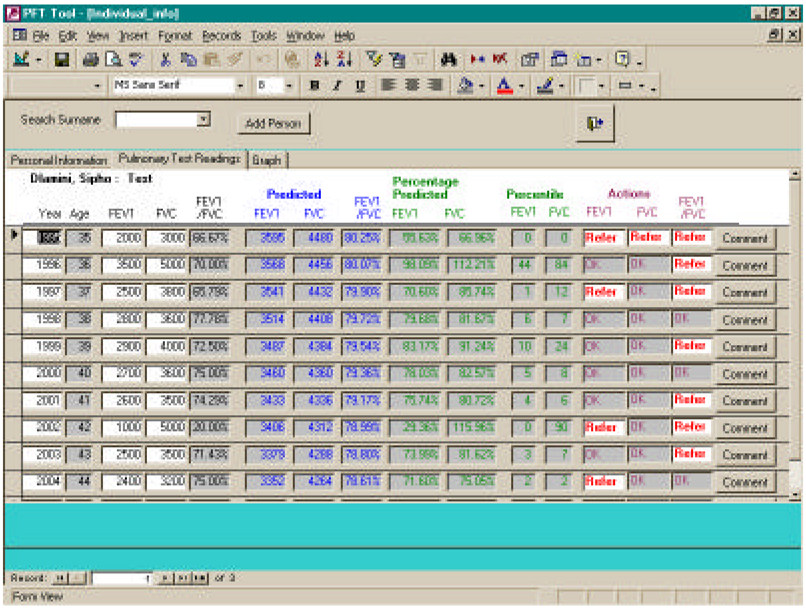
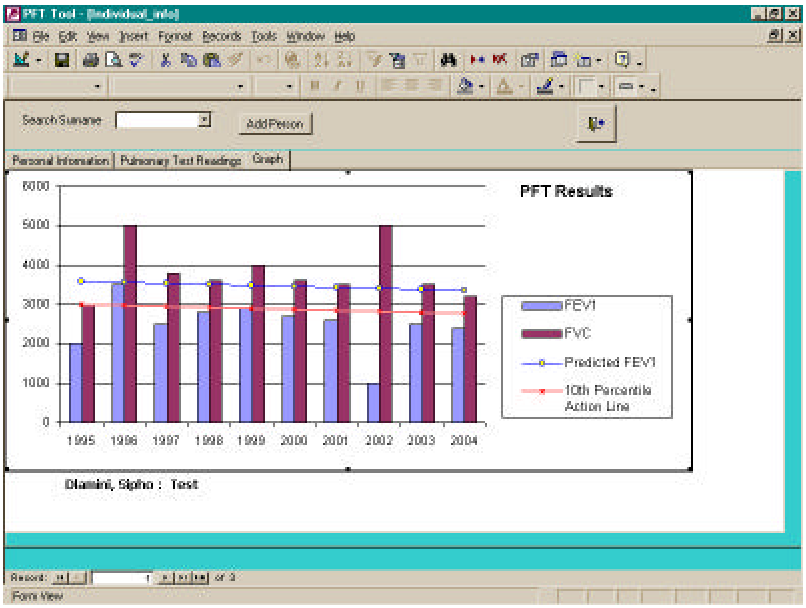


Figure 2.9: SpiroAccess Electronic Chart Screen



SpiroAccess is very similar to SpiroTracker, but is MS Access based, and thus more flexible. It works on a run-time version of Access, which is operable on computers that do not have Access as an installed programme. SpiroAccess has many advantages over its Excel sibling. As a relational database, data can be easily imported from other programmes, and only one file is used for entering, storing and accessing data. Additionally, analytic outputs are easily generated by group, e.g. homogenous exposure group, making epidemiological diagnosis easier. SpiroAccess is still in development at the time of writing this report.

The main advantages of SpiroAccess are that it is fully protectable, and potentially directly interfaceable with spirometric equipment, as well as with any relational databases (e.g. human resources) the mine may be running.

Initial difficulties we had with SpiroAccess were that it was not rugged across computers and platforms. It has not worked reliably on all computers we have used it on. It freezes sometimes for no apparent reason. Additionally, some of the functions that worked flawlessly in Excel would not run in Access, and had to be substituted by a set of programmed commands.

The size of SpiroAccess is currently 2868 kilobytes, compared to the 302 kilobytes of SpiroTracker and 107 kilobytes of SpiroCharter. This means that it cannot be stored on the 1.4MB stiffy or floppy diskettes, and will need to be transmitted by CD. This should present no problem given its intended uses.

SpiroAccess is fully compatible with existing systems on the mines and it is possible to read data from spirometers directly, using their serial RS232 ports. This requires an IT specialist to write a programme/s to glean the appropriate data from the various spirometer models.

3. Discussion and Recommendations

SpiroCharter as it currently stands is largely complete. In itself it fulfils the brief of the HEALTH 805 contract for the development of lung function reference tables suitable for use in the South African mining industry.

SpiroTracker is still subject to IP securing

SpiroAccess needs to be developed further to make it more robust.

Intellectual property considerations are yet to be fully sorted out. SpiroCharter is easily copyrighted. However, SpiroTracker has proved impossible to fully protect due to the nature of the Excel programme. SpiroAccess is still under development requiring finalisation of the program as well as copy protection, which is feasible for Access programs.

The project took an unexpected direction in that what was originally intended as a chart-based tracking system developed into a multi-level computer-based set of products. This developmental work including the piloting and iterative feedback from potential end-users took up most of the time allotted. However, the main aim of the project has been achieved with the production of SpiroCharter, which is available for immediate use and is submitted in both hardcopy and electronic format in this report. Subject to intellectual property concerns, SpiroTracker is similarly available, while SpiroAccess requires further development.

What remains to be done is the marketing of the products to the mining industry. A computer and internet-based marketing programme is envisaged. Users would register for a computer-based training course (using WebCT), and on completion, download the product of choice and register its use. It is recommended that this marketing process develops organically as part of further SIMRAC contracts in the same direction. Additional work in progress over and above the specific objectives of HEALTH 805 has been conducted and will culminate in SIMRAC 020803.

It is hoped that these products will contribute towards an improved surveillance culture on the mines. It is intended that these products be accessible and affordable to operate. Improved surveillance in the final analysis will depend on the will of mine management to engage in meaningful and effective monitoring of occupational hazards and the health of mineworkers. Specifically, this will depend on making full use will be made of all available occupational hygiene and medical data.

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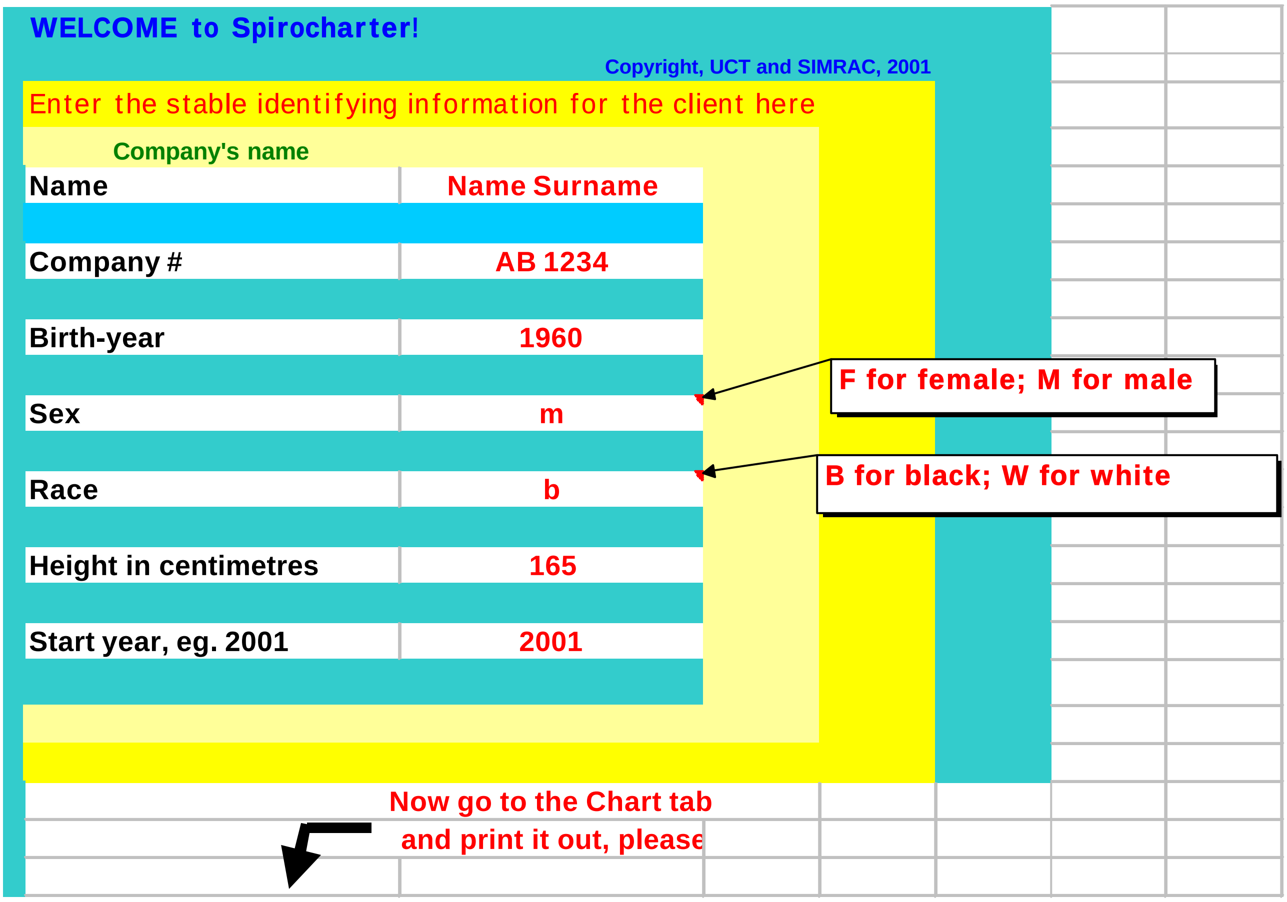
Appendix 1

An example of SpiroCharter

1. The Identity Screen



An example of SpiroCharter

2. The "brains" sheet – not seen by users

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
165	165	165	165	165	165	165	165	165	165	165
41	42	43	44	45	46	47	48	49	50	51
1	1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0
2386.36762	2359.36762	2332.36762	2305.36762	2278.36762	2251.36762	2224.36762	2197.36762	2170.36762	2143.36762	2116.36762
3143	3116	3089	3062	3035	3008	2981	2954	2927	2900	2873
3899.63238	3872.63238	3845.63238	3818.63238	3791.63238	3764.63238	3737.63238	3710.63238	3683.63238	3656.63238	3629.63238
0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4.19398E-10	6.3034E-10	9.44167E-10	1.40948E-09	2.09703E-09	3.10948E-09	4.59521E-09	6.76799E-09	9.9346E-09	1.45338E-08	2.11907E-08
REFER	REFER	REFER	REFER	REFER	REFER	REFER	REFER	REFER	REFER	REFER
3856	3832	3808	3784	3760	3736	3712	3688	3664	3640	3616
0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
REFER	REFER	REFER	REFER	REFER	REFER	REFER	REFER	REFER	REFER	REFER
#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
0.815093361	0.813152401	0.811186975	0.809196617	0.807180851	0.805139186	0.803071121	0.800976139	0.798853712	0.796703297	0.794524336
#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
-6.832608696	-6.773913043	-6.715217391	-6.656521739	-6.597826087	-6.539130435	-6.480434783	-6.42173913	-6.363043478	-6.304347826	-6.245652174
-7.140740741	-7.096296296	-7.051851852	-7.007407407	-6.962962963	-6.918518519	-6.874074074	-6.82962963	-6.785185185	-6.740740741	-6.696296296

An example of SpiroCharter

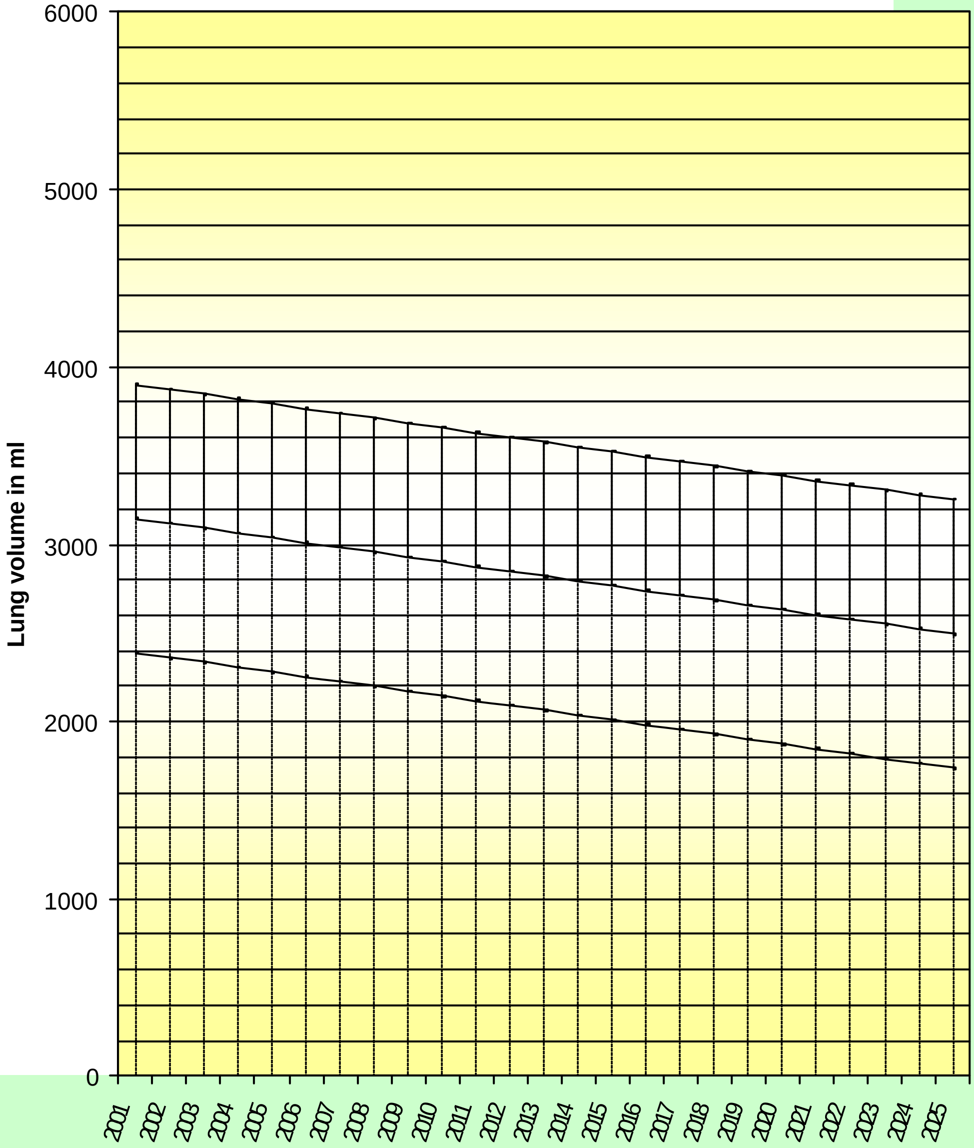
3. The Chart Screen – to be printed out as hardcopy

Company's name

Worker's name	**Name Surname**
Company number	**AB 1234**

Birth year 1960 Height in cm 165

The top sloping line is the 95th centile and the middle line is the predicted.
The lowest line is the lower limit of normal.



Instructions:

1. **Identify the correct year column.**
2. **Make a dot opposite the correct value for FEV1 in ml**
3. **Circle it in red, and connect it up with other FEV1 values.**
4. **Repeat for FVC, but in blue, and make crosses instead of circles.**

Remember that the FVC value is always larger than the FEV1.