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Blood pressure-measuring devices in rural South Africa: an audit conducted by the SASPI team in the Agincourt field site

MD CONNOR, FCNeurol (SA),
Division of Neurology, Department of Neurosciences, University of the Witwatersrand, Johannesburg

T HOPKINS, MB, BCh,
School of Medicine, University of Aberdeen, Scotland

SM TOLLMAN, MMed, MPH, MA,
MRC/Wits (Agincourt) Rural Public Health and Health Transitions Research Unit, School of Public Health, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg

M THOROGOOD, PhD, and
Department of Epidemiology, University of Warwick, England

G MODI, PhD
Division of Neurology, Department of Neurosciences, University of the Witwatersrand, Johannesburg

Summary

Background—Cardiovascular disease is an important cause of morbidity and mortality in South Africa. The Southern Africa Stroke Prevention Initiative (SASPI) found a high prevalence of stroke in the rural Agincourt subdistrict, Limpopo province. Hypertension is the commonest vascular risk factor in our population and it is essential that primary care services be adequately equipped to detect and treat hypertension. The aim of this study was to assess the number, accuracy and working condition of blood pressure-measuring devices (BMD) in the clinics that serve the field site, and to assess the clinic sisters' perceptions of the availability of antihypertensive medication and aspirin.

Methods—In each of the clinics serving the site we assessed the BMDs and cuffs using the following criteria: general condition, bladder size, state of rubber components, operation of the inlet valve and control of valve operation. The legibility of the gauge, level and condition of the mercury, and the condition of the glass tube were checked when relevant. The performance of the BMD was then assessed both with the cuff used in the clinic and with a new functioning cuff, against an accurate mercury sphygomomanometer. By interviewing the clinic sister we could assess the availability of antihypertensive medication and aspirin, as well as the state of the drug delivery system.

Results—All BMDs were mercury sphygmomanometers. Four clinics had one BMD each, one clinic had two, and one clinic had four. In one clinic the device was not functional at all until the study cuff was used. None of the clinics had spare cuffs and only one clinic had access to a large cuff. Nine out of 10 (90%) cuffs tested had unsatisfactory valve function, and none was of the size recommended by the guidelines. Although the condition of the mercury was only considered satisfactory in 40% of BMDs, once a new cuff had been fitted to the BMDs all of them were accurate to within 4 mmHg between 50 and 250 mmHg. Fifty per cent of clinic sisters felt they always had sufficient stock of hydrochlorothiazide and α-methyldopa, but the supply of more expensive medication was less reliable. Only one clinic always had sufficient aspirin.

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Conclusion—Although none of the primary care clinics had fully functioning BMDs, almost all the defects related to malfunctioning and inappropriately sized cuffs, which would be inexpensive to repair or replace. A procedure for routine servicing or replacement of both BMDs and cuffs is needed, as well as optimisation of medication delivery to remote areas.

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Cardiovascular disease is the second commonest cause of death in South Africa.1 Both the morbidity and mortality related to vascular disease is likely to increase as the South African population undergoes a health transition. Disability related to stroke, the vascular condition which spearheads the transition, is already at least as prevalent in rural South Africa as in high-income regions of the world.2 Underlying the initial rapid increase in vascular disease in a population is a risk-factor profile dominated by hypertension, and this was clearly evident in rural stroke survivors in the Southern Africa Stroke Prevention Initiative (SASPI) stroke prevalence study. Seventy-one per cent of 103 stroke survivors had evidence of hypertension and a further 13% had clinical evidence of hypertensive end-organ damage or had been on antihypertensive therapy in the past. Only eight out of 73 hypertensive stroke survivors were on antihypertensives and only one had a blood pressure less than 140/90 mmHg.3

As part of the SASPI study, we held workshops with nurses from the health centre and the five primary care clinics that serve the Agincourt subdistrict of Bohlabelo district, Limpopo province, where our research was based. The aim of these workshops was to explore barriers to the management of stroke, hypertension and diabetes mellitus. Problems the nurses identified included the lack of reliable blood pressure-measuring devices and an unreliable medication supply.3 The latter supported our previous observations in the stroke prevalence study where stroke survivors had complained about the irregular drug supply at clinics.3

To adequately address the prevention of vascular disease in our population, the primary health service must be adequately equipped to detect and treat hypertension. The aim of this study was to assess the number, accuracy and working condition of blood pressure-measuring devices (BMD), and whether appropriate cuff and bladder sizes were available in the rural clinics that serve the Agincourt subdistrict. These clinics make up a subdistrict ‘network’ of facilities; such subdistrict systems are the building blocks for district healthcare in South Africa and the necessary basis for any effective health service response to cardiovascular risk management.4 We also carried out a qualitative assessment of the availability of antihypertensive medication and aspirin in these clinics.

Methods

Ethics approval

Research in the Agincourt subdistrict (MRC/Wits field site), including research involving the development and evaluation of health services, was approved by the University of the Witwatersrand Human Research Ethics Committee: M960720. The study was also approved by the regional director of health in the Bohlabelo district, and by the sister in charge of each clinic and the health centre in the subdistrict.

Population and setting

The MRC/Wits (Agincourt) Rural Public Health and Health Transitions Research Unit is based in the Bohlabelo district of Limpopo province, where health and demographic surveillance monitoring of all vital population events has been underway since 1992.5 The field site includes 21 villages that range in size from 100 to 1 100 households (total population about 70 000 people). Electricity is available in most villages but not in all households, while access to clean water is severely limited. There are five publicly funded primary care clinics and a larger referral health centre staffed by nurses, with infrequent

visits from doctors. Together these facilities make up the subdistrict primary care network of services and all were included in the study. Treatment and drugs are free at these clinics and the health centre. Three district hospitals, which act as secondary care (referral) facilities, and a number of private practitioners also serve the Bohlabelo district but were not included in the study.

Assessment of BMD in clinics

In each of the five clinics and the health centre, we assessed the number and type of BMDs as well as the range of cuff sizes available. We then assessed the accuracy and working condition of the BMDs according to methods previously used by recognised authorities in the field.6 The cuff and bladder were examined as described in Table I. The condition of each BMD was assessed (Table II) as well as its operation (Table III). Each BMD was tested with both the cuff with which it was used in the clinic, and with a new, fully functioning cuff.

The accuracy of the BMD was tested at 20 mmHg increments across a range of pressures from 50 to 250 mmHg against an OMRON 12-605TK (Kyoto, Japan) mercury sphygmomanometer that was known to be accurate. The only change we made to the method of assessment used by Burke *et al*.6 was to place the cuff *within* rather than *around* a bottle during inflation. This approach was suggested by a researcher who had recently completed an assessment of BMDs in general practice in the United Kingdom7 (Dr P McCartney).

A component was classified as ‘satisfactory’ if it was in good working order, and ‘unsatisfactory’ if there was dirt, undue wear, or damage that prevented correct operation of the BMD. We chose this classification both to keep our assessments comparable with previous studies,6 and because we felt it was more important to know whether the equipment was in ‘good working order’ than in ‘perfect condition.’

Assessment of availability of medication in clinics

We assessed the availability of antihypertensive medication and aspirin by interviewing the sister in charge of the clinic using a questionnaire. The questions we asked covered the availability of medication in general as well as questions about the drug distribution system and problems encountered with the system.

Results

Blood pressure devices

We assessed the blood pressure-monitoring equipment in all six primary care facilities (the five clinics and one health centre are considered as six ‘clinics’ in the results) supporting the Agincourt subdistrict. All the blood pressure-measuring devices were mercury sphygmomanometers and none of the clinics had digital or aneroid devices. Four clinics had one sphygmomanometer each, one clinic had two, and one clinic (the referral health centre) had four. In one of the clinics that only had one sphygmomanometer, the device was not functional until the new study cuff was used. The other devices were apparently in working order.

None of the clinics had spare cuffs and only one clinic had access to a large cuff. The condition of the available cuffs and bladders is described in Table I. Defects were common, with almost all cuffs having some problem with the valve operation, rendering it faulty. The British Hypertension Society recommends that a standard adult bladder size should be 12 × 26 cm,8 and the South African Hypertension Guidelines recommend a 12-cm cuff in a

normal adult, provided the bladder within the cuff encircles 80% of the arm.9 The cuffs available did not meet these recommendations.

Tables II and III describe the general condition of the sphygmomanometers and their accuracy. Despite apparent wear and tear, the devices were all accurate across the range of pressures assessed once the new study cuff had been fitted; then the gauge component of the sphygomanometers was accurate to within 4 mmHg in all the devices tested. Without the study cuff fitted, however, when all aspects of the assessment were combined, not one of the BMDs was in satisfactory working condition.

Medication

In Limpopo province, people diagnosed with hypertension might receive their medication through one of two routes. Clinic sisters have access to and may dispense a limited number of antihypertensives directly, specifically hydrochlorothiazide and α-methyldopa (route 1); as specified in the Essential Drugs List.10 This medication is ordered in bulk by the clinic from the central pharmacy on a monthly basis. Aspirin is available via route 1.

If, however, patients require referral to one of the district hospitals to see a doctor, they then receive repeat prescriptions from the clinic for the months before their next appointment with the doctor. In this case the clinic receives the medication (usually the more costly antihypertensives) from the central pharmacy on a monthly basis for this patient (route 2).

Half of the sisters (three) felt that they always had enough hydrochlorothiazide and α-methyldopa available, whereas the other half felt that they tended to run out of stock. Only one clinic sister felt that her clinic always had sufficient stocks of aspirin. The major problem with both route 1 and 2 was late delivery of medication. At the time of our visit, two of the clinics had not received the previous month's medication and were running very low on all medications. All clinics complained about the erratic delivery of drugs, and a problem with transport was blamed for most of the delays. Further difficulties were experienced with route 2 prescriptions. They were often inadequate; insufficient amounts of the more expensive medication arrived, or medication did not arrive at all.

Discussion

We found that none of the primary care clinics supporting the Agincourt subdistrict of the Bohlabelo region of Limpopo province had fully functioning blood pressure-measuring devices. However, almost all of the defects found related to malfunctioning and inappropriately sized blood pressure cuffs and bladders and not to the sphygmomanometers themselves. This finding has an important practical implication, because replacement of cuffs is far less expensive than replacement of the entire blood pressure-measuring device. We also found a severe shortage of large cuffs. This was particularly important since there is a high prevalence of obesity among women in the area. In a population survey we found that 30% of women aged over 35 years were obese (had a waist circumference > 88 cm).11

The sisters in charge of the clinics reported problems with the supply chain of antihypertensive medication and aspirin from the central pharmacy and referral centres to the clinics, although since our study was carried out, a new computerised supply system has been installed in primary care facilities of the district and province. Hydrochlorothiazide and α-methyldopa were the most readily available antihypertensive agents in the clinics. The latest South African Hypertension Guidelines, compiled with a representative of the Department of Health, recommend that α-methyldopa should be used only for resistant hypertension.9 The medication available in primary healthcare clinics will therefore have to be reassessed in line with the new guidelines.

Although there is a worldwide trend towards replacing mercury sphygmomanometers because of concern about the toxic effect of mercury on the environment,12 there is also concern about the practicality of validated digital replacement devices and the provision and toxic effects of the batteries that they require.9 Certainly mercury sphygmomanometers are preferable to the inaccurate aneroid devices6 and are likely to be found in most primary care clinics around South Africa for some time to come.

Mercury sphygmomanometers are basically accurate devices if serviced and maintained. Table IV shows the potential sources of error, the resultant effects on blood pressure readings and possible solutions. All sources of error noted in Table II, such as the level of the mercury and the condition of the glass are eliminated by servicing. Indeed, these problems need not render the sphygmomanometers inaccurate, as was found in our study and in previous studies.6 However, they do make blood pressure interpretation more difficult. Although we did not plan to study the clinic sisters' knowledge of mercury toxicity, we did observe that they were unaware of the potential dangers and did not know that the mercury devices should be disposed of with care.

The single most important defect in the BMDs studied was found in the functioning of the pump bulb inlet valve and control valves. This has been found in other studies6 and is easily corrected by cleaning, or inexpensive replacement of the valve. Furthermore, even if at some time in the future clinics change to using digital devices, this problem would still need to be addressed. Cuff size and condition was also of concern, with none of the cuffs in the study meeting standard criteria and only one clinic having access to a large cuff. If the cuff size is too small then blood pressure is overestimated (undercuffing) and if it is too large the blood pressure is underestimated (overcuffing).8 The problem in our study, as has been noted in other studies, was with a smaller-than-acceptable standard adult cuff size.6,7

On the basis of our findings we made the following recommendations regarding BMDs:

- When new BMDs are purchased, the health service purchasers must insist on the correct cuff/bladder sizes accompanying the products.
- All faulty and inappropriate cuffs must be replaced on existing BMDs.
- A procedure for the routine servicing of BMDs, with replacement or repair of faulty cuffs should be established and maintained; and if a procedure already exists, then reasons for its inadequate function need investigation.
- Clinic sisters should be advised regarding the dangers of mercury spillage.
- A procedure must be established for disposal of old and faulty mercury sphygmomanometers.
- Audits of BMDs should be done in other clinics as well as in hospitals in South Africa.
- Doctors and nurses should be educated about the potential sources of error that may occur with the mercury sphygmomanometer and other blood pressure devices.
- Attention must be given to ongoing supervision and support of primary care staff responsible for blood pressure measurement.

The division of the health service into primary care and secondary referral care with rationalisation of medication available at the different levels is fundamental to our public health service.10 However, a constant supply of basic antihypertensive medication and aspirin, which is the cornerstone of prevention of many chronic vascular conditions, is essential at the clinic level. An uninterrupted supply of chronic medication is crucial to good patient management at any level of care.

Difficulty in providing adequate drug supply is well recognised as occurring in rural and developing country settings. The urgency for overcoming these difficulties has been highlighted by the transition in low- and middle-income populations towards a more chronic disease and risk-factor profile.13 The maintenance of a constant supply of medication to remote clinics and people living in more isolated regions of South Africa is a challenge, but one which is clearly stimulating both administrators and researchers to find locally appropriate solutions. The newly installed system may resolve some of the problems we encountered and should be evaluated once it has been in place for a period of time.

The prevalence of hypertension is already at alarming levels in South Africa14,15 and it remains the most important modifiable risk factor for stroke and other chronic vascular diseases, which are expected to increase dramatically in the future.13 If we are to address this increase by efficient primary and secondary prevention, then our health service must be able to accurately measure and treat hypertension. Although further work is required to establish appropriate BMD servicing procedures and medication provision, our findings suggest that this can be done without excessive cost, and the obstacles to developing adequate primary chronic care services in such rural and remote settings may be lower than is currently anticipated.

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TABLE I

ASSESSMENT OF THE CONDITION OF CUFFS AND BLADDERS

Component	*Test*	*Satisfactory n = 10 (%)*	*Unsatisfactory n = 10 (%)*
Cuff	Examine general condition of the cuff and ability to fasten around arm	8 (80)	2 (20)
Bladder size	Measure bladder dimensions and compare with standard	0 (0)	10 (100)
State of rubber components	Check the state of the rubber components	5 (50)	5 (50)
Pump bulb – operation of inlet valve	Check operation of inlet valve	1 (10)	9 (90)
Control valve operation	Check operation of control valve	5 (50)	5 (50)

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TABLE II

CONDITION OF SPHYGMOMANOMETERS

Component	*Test*	*Satisfactory (%)*	*Unsatisfactory (%)*
Gauge	Check legibility of gauge	10 (100)	0 (0)
Mercury	Check level of mercury and general condition	4 (40)	6 (60)
Glass tube condition	Examine tube for dirt	9 (90)	1 (10)

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TABLE III

PERFORMANCE OF SPHYGMOMANOMETERS

		Old cuff, n = *10 (%)*		*New cuff*, n = *10 (%)*	
Function	***Test***	***Satisfactory***	***Unsatisfactory***	***Satisfactory***	***Unsatisfactory***
Inflation	Place cuff in bottle and test ease of inflation and ability to halt and restart at any pressure	7 (70)	3 (30)	10 (100)	0 (0)
Deflation	Rate of fall of mercury should be easily controlled to 2 mmHg/s	8 (80)	2 (20)	10 (100)	0 (0)
Leakage	Inflate the cuff pressure to 250 mmHg within the tube. No more than 10 mmHg should be lost in 10 s	6 (60)	4 (40)	10 (100)	0 (0)
Gauge accuracy	Disconnect the gauge and connect via a Y-tube to the accurate mercury manometer. Test at 20-mmHg increments from 50–250 mmHg. More than a 4-mmHg discrepancy is unsatisfactory	Not applicable	Not applicable	10 (100)	0 (0)

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TABLE IV

POTENTIAL SOURCES OF ERROR IN A MERCURY SPHYGMOMANOMETER6,8

Source of error	***Effect on blood pressure reading and use of the device***	***Possible solution***
A. Pressure gauge components		
Mercury may leak from the gauge Oxidation of mercury on glass tube causing mercury to adhere to the tube	Underestimation of pressure Overestimation of pressure Difficulty reading pressure	Add mercury * Replace mercury, clean tube with pipe cleaner and methylated spirits *
Blockage of air vent (prevents air entering into the glass tube when the pressure is released)	Overestimation of pressure makes inflation difficult – mercury slow to respond to an increase or decrease in pressure	Clean vent or replace leather
B. Cuff and bladder components **		
Rubber components – leakage of air	Difficulty controlling the release of pressure Underestimation of systolic and overestimation of diastolic pressure	Replace components
Pump bulb inlet valve – blockage or leak	Difficulty inflating the cuff	Clean/replace bulb or valve
Defective or leaking control valve	Difficulty controlling the release of pressure Underestimation of systolic and overestimation of diastolic pressure	Clean/replace valve
Bladder too small for patient's arm: *undercuffing*	Overestimation of blood pressure	Use appropriate cuff size
Bladder too large for patient's arm: *overcuffing*	Underestimation of blood pressure	Use appropriate cuff size

* Mercury is toxic to individuals and the environment12 and the appropriate personnel/department should service mercury devices. We do not recommend that medical staff attempt to clean the glass tubes or replace the mercury.

** Faults in cuff and bladder components are not specific to mercury sphygomomanometers.