

Orthopaedic referrals using a smartphone app: Uptake, response times and outcome

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Background. It is well established that South Africa (SA) suffers an immense burden of violence and injuries. The responsibility of providing care for these injuries falls mainly on public health services, resulting in overloading of the health system. Prior to a recent intervention, the large burden had been exacerbated by limitations in the traditional referral system that highlighted the need for a better referral system. Vula's smartphone app was introduced at Tygerberg Hospital in August 2016. This study evaluated the uptake, response times and outcomes using this app.

Objectives. The main objectives of the study were to describe: (i) the number of referrals; (ii) referral response times; (iii) referring facilities; and (iv) referral outcomes. Secondary objectives were to: (i) evaluate whether the referral outcome pathway was appropriate; and (ii) assess professional conduct and evidence of upskilling.

Methods. This retrospective, descriptive study investigated Vula app referrals to the Division of Orthopaedic Surgery at Tygerberg Hospital between 1 August 2016 and 31 March 2017. Vula was advertised to key facilities in the hospital's referral network. All referrals to the division during the study period were systematically included in the analysis of operational outcomes, although some were excluded from the subsequent referral outcome analysis. Operational outcomes included the number of referrals, referring facilities and referral response times. Referral outcome analysis included the clinical diagnosis, referral pathway, whether the referral was used for upskilling and whether it was conducted in a professional manner.

Results. A total of 2 275 referrals from 39 different facilities were received during the study period from 238 individual users; 50% of referrals received a response within 11 minutes, while a small percentage received no response. Clinical and demographic characteristics of 1 985 patients included in the referral outcome analysis indicated that the majority of trauma and emergency referrals involved males, with closed fractures being the most frequent clinical presentation. Although the most common referral outcome was immediate transfer, one-third of the patients were treated at the referring hospital with advice only.

Conclusions. The large volume of orthopaedic referrals received through the Vula app suggests that Vula represents a successful alternative to traditional referral methods. Referrals managed by advice only could suggest that Vula facilitates some relief for the overburdened trauma services. Future research could further explore Vula's role in strengthening the public health system, including interventions for high-volume referral areas and upskilling of referring health workers.

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It is well established that South Africa (SA) suffers from an immense burden of violence and injuries, with an estimated 157.8 injury deaths per 100 000 population in the year 2000.^[1-3] This injury mortality rate was notably higher than the 139.5 injury deaths per 100 000 for the African continent as a whole and almost double the global average of 86.9 per 100 000 over the same period.^[1] Nevertheless, deaths due to injury represent only a small fraction of all injuries, and much larger numbers of patients would have required treatment for non-fatal injuries.^[4] While less is known about the burden of non-fatal than fatal injuries in SA, a previous estimate suggested a trauma caseload of >3 million per year^[5] and local studies have confirmed a high burden of trauma in Western Cape Province.^[6,7] The responsibility of providing care for these injuries falls mainly on the public health services^[8] that deliver care to 84% of the population,^[9] including tertiary-level facilities such as Tygerberg Hospital in the Western Cape. Tygerberg Hospital serves approximately half of the province, including the eastern and northern parts of the Cape Metro and three rural districts – a catchment area population of >3.4 million.^[10] While the hospital itself is a level 1 trauma centre with highly specialised

services, certain peripheral health facilities in the hospital's catchment area have limited expertise^[11,12] and frequently refer patients to this tertiary facility for primary- and secondary-level trauma care. This situation has resulted in considerable strain on trauma services at the hospital, with internal audits indicating that the Division of Orthopaedic Surgery managed 1 100 - 1 400 trauma and emergency cases per month in 2016.

Prior to a recent intervention, the large burden of trauma and emergency cases had been exacerbated by limitations in the traditional referral system – telephone-based referrals via the hospital switchboard. For the referring health worker, telephone referrals involved lengthy, unproductive time spent waiting on the line and the risk of dropped calls, whereas for the responding registrar they meant the added pressure of attending a landline connection while managing emergency cases. Further challenges of telephone referrals included medicolegal concerns such as supplementary use of WhatsApp or MMS (Multimedia Messaging Service) to share confidential patient images^[13-16] and no record of the information provided or treatment plans prescribed during a telephonic discussion. These problems

clearly highlighted the need for a better referral system that could address the existing issues and assist with clinical decision-making. It was envisaged that this in turn would help to avoid unnecessary transfers and so relieve some of the burden on the overloaded tertiary trauma services.

The intervention subsequently adopted was to incorporate the Vula smartphone app (www.vulamobile.com) as part of standard operating procedure for orthopaedic trauma and emergency referrals to the registrar on call. Developed in response to the challenges of rural healthcare in SA, the POPI (Protection of Personal Information Act)-compliant app was intended to provide quick access to specialist advice and an efficient means of referral between health workers and specialist care. Although it was originally designed for ophthalmology referrals, Vula has since been expanded to over 16 specialties, each with its own custom-designed referral template for clinical information and images. Further details of the app and considerations around its use for burn referrals have been published elsewhere.^[15,17] In August 2016, the Division of Orthopaedic Surgery at Tygerberg Hospital was the first orthopaedic department to introduce referrals via the app, and awareness of this new referral option was specifically promoted through visits to key health facilities in the hospital's referral network. In theory, Vula had several advantages over traditional phone-based referrals. For example, more structured, relevant clinical information and images may have allowed for more informed clinical decision-making and increased scope for up-skilling the referring health worker.^[15] Furthermore, use of a personal smartphone rather than a landline may have been more convenient for referring health workers and improved response times from the registrar on call. However, in practice little was known about the outcomes of referrals through Vula and whether this referral method appeared to be useful and clinically safe for orthopaedic trauma and emergency referrals in the Western Cape public health context.

Objectives

The main objectives of this study were to describe: (i) the number of referrals; (ii) referral response times; (iii) referring facilities; and (iv) referral outcomes. Secondary objectives were to: (i) evaluate whether or not the referral outcome pathway was appropriate; and (ii) assess professional conduct and evidence of upskilling within the referrals.

Methods

Study design

This retrospective, descriptive study investigated Vula app referrals to the Division of Orthopaedic Surgery at Tygerberg Hospital between 1 August 2016 and 31 March 2017. This period coincided with adoption of Vula as part of standard operating procedure for trauma and emergency referrals and use of the app over the first 8 months of implementation.

Setting

Tygerberg Hospital is one of two level 1 trauma centres in the Western Cape and serves approximately half of the province. Other established public orthopaedic services in the hospital's catchment area at the time of the study were Paarl Hospital, Worcester Hospital and to a lesser extent Khayelitsha Hospital. The introduction of Vula was advertised to key hospitals and clinics in the Tygerberg Hospital referral network. Clinicians who referred via the traditional pathways were informed about the Vula app by the orthopaedic registrar and encouraged to start using it. However, traditional referral platforms remained in place alongside Vula, so that referring health workers were free to choose their preferred method of referral.

Referrals

All Vula referrals to the Division of Orthopaedic Surgery at Tygerberg Hospital during the study period were systematically included in the analysis of operational outcomes. However, inappropriate referrals, referrals with missing data, duplicate referrals and test referrals were excluded from the subsequent referral outcome analysis. The aforementioned referrals were included in the operational analysis as they contributed to the overall burden of referrals to be assessed by the registrar on call. However, they could not be meaningfully analysed for the referral outcomes. For example, inappropriate referrals included elective referrals rather than trauma or emergency referrals. Referrals with missing data included instances in which the referral did not receive a response from the orthopaedic registrar, or a question posed by the registrar that received no response from the referring health worker. Inclusion of duplicate referrals would have introduced error into the description of referral outcomes, and test referrals were those in which users were clearly experimenting with the app's functionality rather than submitting a genuine referral.

Data collection

A dataset of all Vula referrals to the Division of Orthopaedic Surgery during the study period was obtained from the operators of Vula Mobile. No patient identifiers were included in the dataset. Extraction of the data was therefore compliant with POPI, as POPI does not apply to anonymised data. However, the dataset contained administrative data such as referral date, time and referring facility. Furthermore, it included clinical and demographic data for each patient referred and the communication between the referring health worker and orthopaedic registrar on call via the 'chat' function of the app. All referrals were analysed and any points of uncertainty during the referral analysis were noted and subsequently resolved in consultation with a senior consultant. Referral outcomes were captured into a predesigned Excel spreadsheet, version 2010 (Microsoft, USA), using drop-down menus.

Operational outcomes

Operational outcomes determined directly from the dataset included the number of referrals, referring facilities and referral response times. Referral response time represented the time period between submission of the referral by the referring health worker and the first reply from the orthopaedic registrar.

Referral outcomes

The demographic characteristics of referred patients were determined directly from the dataset. Furthermore, chat communication between the referring health worker and the registrar was analysed to determine the clinical diagnosis, the referral pathway and the appropriateness of the pathway chosen. Referrals were categorised as accepted for immediate transfer to Tygerberg Hospital, booked for an orthopaedic outpatient appointment at Tygerberg Hospital, or managed by providing recommendations for further care at the referring facility ('advice only'). The referral pathway allocated was subsequently categorised as 'appropriate' or 'inappropriate' according to whether the decision made was agreed upon by the registrar performing the analysis. This evaluation was informed by an initial training period during which the registrar assessed referrals together with a senior consultant.

Additional outcomes from analysis of chat communication included whether the referral was conducted in a professional manner and whether the referral had been used as a means of upskilling the referring health worker. Black's Law Dictionary describes professional

conduct as the accepted manner in which a professional will act,^[18] and for medical professionals, this includes aspects such as accepting responsibility and showing respect for patients.^[19] Using these concepts and the Health Professions Council of South Africa's core ethical values and standards for good practice^[20,21] as reference, referrals were categorised as 'professional conduct' or 'unprofessional conduct'. Upskilling is defined by the Cambridge Dictionary as a process of teaching new skills.^[22] In the context of the referrals, cases in which the referring health worker was given additional information, feedback or help over and above what was needed to make the diagnosis and referral arrangements were categorised as 'upskilling', whereas the absence of this aspect was categorised as 'no upskilling'.

Data analysis

Categorical data were presented as frequencies (%), whereas continuous data were tested for normal distribution and presented as means and standard deviations or medians and interquartile ranges, as appropriate. All statistical analyses were performed in Graphpad Prism version 6.00 (GraphPad Software, USA).

Ethical considerations

The study was approved by the Health Research Ethics Committee of Stellenbosch University (ref. no. S17/01/019) and the management of Tygerberg Hospital. The dataset of Vula referrals made available for the study did not include any patient-identifying information such as the names, medical record numbers or contact information of those referred, to protect patient privacy and confidentiality.

Results

Operational outcomes

A total of 2 275 referrals were received during the study period, with a progressive increase from 108 referrals in the first month to 401 in the eighth month of implementing Vula (Fig. 1A). Referral response times were skewed towards quicker responses, with 50% of referrals receiving a response within ~11 minutes each month (Fig 1B). However, the time frame for 'slower' responses decreased over the study period, with 75% of cases receiving a response within 58 minutes in the first month v. 22 minutes in the 8th month (Fig. 1B). Although a small number of referrals per month received no response, this decreased from 10% of referrals in the first month to ≤3% from the 4th month onwards.

Referrals were received from 39 different facilities, including 15 hospitals and 22 primary healthcare facilities. Most referring facilities were within the Cape Metro (n=32, 82%), with the distribution of referrals by facility that submitted ≥5 Vula referrals over the study period shown in Fig. 2. There were 238 individual users who submitted referrals through Vula and 25 registrars at Tygerberg Hospital who responded to Vula referrals.

Referral outcomes

Of the 2 275 referrals received, 290 were excluded from the referral outcome analysis (Fig. 3). Referrals excluded due to missing data were distributed throughout the 8-month study period rather than concentrated at the start of implementation. Clinical and demographic characteristics of the 1 985 patients included in the referral outcome analysis indicated that the majority of trauma and emergency referrals involved males (n=1 260, 63%), with closed fracture the most frequent clinical presentation (n=1 254, 63%) (Table 1). Although the most common referral outcome was immediate transfer (n=899, 45%), one-third of the patients were treated at the referring hospital with the advice given by the registrar on call, without any need for

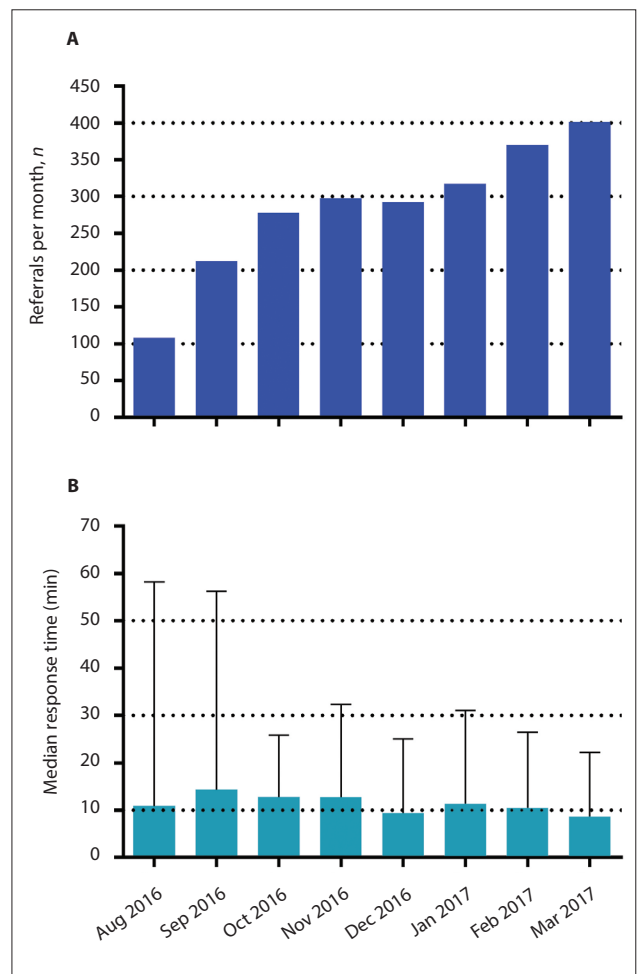


Fig. 1. (A) Number of Vula referrals per month, and (B) Vula referral response times per month. Response times are presented as median and 75th percentile.

Table 1. Clinical and demographic characteristics of patients referred through Vula

	Complete referrals (N=1 985)
Demographics	
Age, median (IQR)*	32 (18 - 47)
Male gender, n (%)	1 260 (63.5)
Clinical diagnosis, n (%)	
Closed fractures	1 254 (63.2)
Infections	257 (12.9)
Open fractures	169 (8.5)
Soft-tissue injuries	167 (8.4)
Dislocations	91 (4.6)
Other	48 (2.4)

IQR = interquartile range.
*Missing data (n=3).

review at Tygerberg Hospital (Fig. 4). Verification of the referral outcome confirmed that the pathway chosen was appropriate in 1 919 cases (97%). Furthermore, 1 977 referrals (>99%) were conducted in a professional manner, and 522 (26%) contained evidence of upskilling. Cases identified as unprofessional conduct ranged from obvious unprofessional behaviour to subtle unprofessionalism. Examples

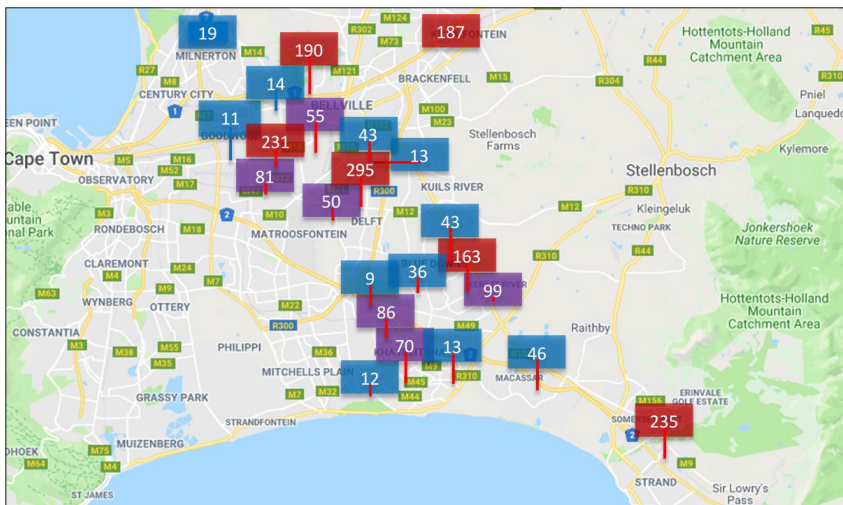


Fig. 2. Vula referrals by facility within the Cape Metro. Only facilities with ≥ 5 referrals during the study period are shown. Blue labels indicate < 50 referrals, purple labels 50 - 99 referrals and red labels ≥ 100 referrals.

included referring doctors being told to re-refer the next day, threatening referring doctors with archiving referrals, blaming peripheral services for blocking beds at tertiary institutions, and not being sensitive to challenges faced by district or regional healthcare services. There was also a case where a registrar on call took personal offence to the referring doctor's conduct and responded in a menacing manner. Examples of upskilling included giving the reasoning behind a decision made, sending photos and instructions on how to apply a certain method of casting for some fracture patterns, providing detailed treatment instructions with acceptable parameters of management, and sending feedback to the referring doctor after clinically reviewing a patient.

Discussion

The first finding of the study was that the Division of Orthopaedic Surgery at Tygerberg Hospital received 2 275 trauma and emergency referrals via the Vula app over the study period, involving 39 different health facilities and 238 referring health workers. When compared month to month, there was an almost four-fold increase from 108 referrals in August 2016 to 401 in March 2017. Response times improved despite the increasing number of referrals, with 75% of referrals receiving a response within 58 minutes in the first month v. within 22 minutes by the 8th month. The growing number of referrals in a short space of time suggests that health workers were comfortable with using the app and that Vula represents a successful alternative to traditional referral pathways.

The second finding of the study was that 647 patients, one-third of those referred, could be treated at the referring hospital or clinic with advice provided by the registrar on call. Avoiding unnecessary transfers to Tygerberg Hospital is a key component in relieving some of the burden on these tertiary trauma services. Furthermore, treating patients at the referring facility would have avoided transport costs as well as the higher cost of tertiary-level care,^[23] thereby reducing the overall cost to the health system.^[13] The patient outcome associated with advice-only referrals was not investigated further. However, the finding that the referral pathway allocated was appropriate in 97% of cases suggested that clinical decision-making based on Vula referrals appeared to be sound.

Other notable findings from the study were that professionalism was maintained in 99% of the referrals reviewed and that registrar feedback through the app was used as a form of upskilling in ~ 1 in 4 cases. Although these outcomes are somewhat subjective, they are important aspects of the daily environment in the healthcare system and provide further insight into the use of Vula. For example, professional conduct on Vula may help to create trust between colleagues and improve future collaboration within common referral networks. Conversely, upskilling through Vula has potential to inform future management of cases with a similar presentation, possibly improving future patient care and reducing dependence on Tygerberg Hospital consultations and transfers.

The current study was the first to assess orthopaedic referrals through the Vula app, and there was little existing literature to

which the findings could be compared. For instance, although there are numerous examples of teleconsultation in other medical specialties,^[24] there appeared to be little existing literature on mHealth in orthopaedics referrals. Previous studies relating to the Vula app have focused on considerations around its use for burn referrals^[15,17] and did not report outcomes such as referral distribution and referral outcome as in the current study. It is noted, however, that qualitative research on expectations around the app identified a possible role for education through Vula^[15] – a suggestion supported through evidence of upskilling in some of the current referrals. Patient demographic characteristics observed in the current study are in keeping with previous trauma studies in our setting, including a predominance of male patients aged < 40 years.^[6,7,25] However, the current study was among the first to describe the clinical diagnosis of orthopaedic trauma referrals, with previous studies focusing largely on mechanism of injury.^[6,7,25]

There were no retrospective records of telephone referrals against which the Vula referrals could be compared. It was therefore not possible to evaluate what proportion of all orthopaedic trauma and emergency referrals were received via Vula, how Vula response times compared with waiting times for landline referrals, or what proportion of landline referrals were managed with advice only. While the extent of the differences was unclear, it was anticipated that referrals via the app would have resulted in less unproductive time for the referring health worker and that the structured presentation of the clinical information and images in the app would facilitate confidence in clinical decision-making, including an advice-only referral outcome.

While collecting data on telephone referrals would be challenging and labour intensive, the automatic, permanent record of all Vula referrals provided valuable information for auditing and health system strengthening. For example, mapping of referrals in the current study showed that Helderberg Hospital and Karl Bremer Hospital were among the top contributors of trauma referrals to Tygerberg Hospital and should be prioritised for strengthening of orthopaedic services. A further benefit of the record of Vula referrals was that it created accountability and increased medicolegal safety for both the referring health worker and the responding registrar. Although these aspects were not directly addressed in the current study, they may partly account for

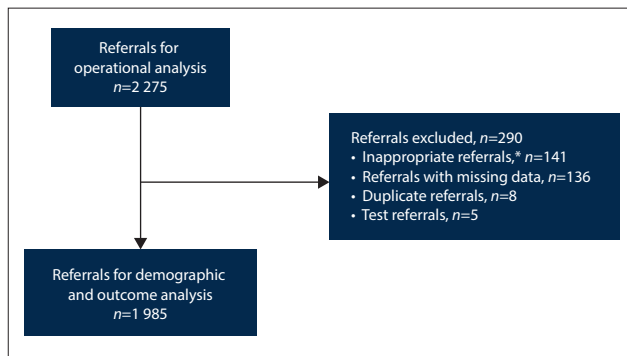


Fig. 3. Screening of Vula referrals for operational, demographic and outcome analysis. (*Inappropriate referrals: n=137 elective, n=4 other.)

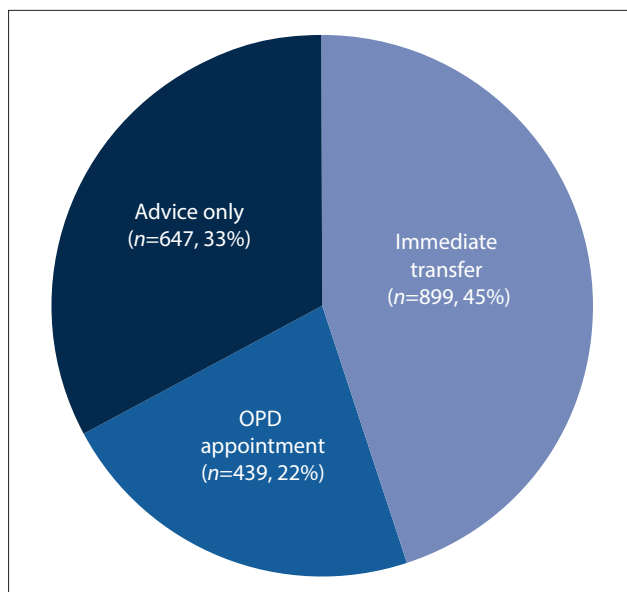


Fig. 4. Outcome of Vula trauma and emergency referrals. (OPD = outpatient department.)

the relatively rapid referral response times and the high prevalence of professional conduct in interactions recorded in the app. Considered collectively, these and other advantages of Vula over traditional referral methods may help to explain the exponential uptake of the app within the wider SA health system. For example, as of November 2018, Vula had >5 500 users in six provinces, with 17 specialties available through the app and >6 200 patients referred via Vula each month (Dr W Mapham, Vula Mobile, personal communication). Furthermore, the app had also been formally adopted as a referral mechanism by the Western Cape Department of Health.

Study limitations and strengths

Limitations of the current study included the fact that there were no retrospective records of telephone referrals against which the Vula referrals could be compared and no previous studies against which the current Vula findings could be compared. Furthermore, analysis of the Vula referrals was dependent on the quality of the data provided by the referring health worker and not all legitimate referrals could be included in the outcome analysis owing to missing data. While the exclusion of referrals with missing data may introduce bias into the distribution of referral outcomes, only 6% of referrals were excluded on this basis and any associated effect would be correspondingly small. Conversely, strengths of this study included the large number

of referrals included and the consistency of information available for each referral due to the pre-set referral template.

Conclusions

The large volume of orthopaedic trauma and emergency referrals received through the Vula app and the acceptable median response time suggest that Vula represents a successful alternative to traditional referral methods. Furthermore, the finding that one-third of referrals were managed by giving advice over the app only could suggest that Vula facilitates some relief for the overburdened trauma services at tertiary level. With 97% of referral pathways verified as appropriate, the app appeared to be a sound tool for clinical decision-making and had the added advantage of a permanent record of referrals for accountability and medicolegal purposes. Although the volume and origin of Vula referrals did not account for the additional referrals received via traditional methods, analysis of Vula referrals may nevertheless provide important insight for quality control and resource allocation. Future research could further explore the role of Vula in strengthening the public health system, including interventions for high-volume referral areas and upskilling of referring health workers.

Declaration. This publication will be submitted as part of the requirements for RWM's MMed (Orthopaedic Surgery) degree.

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Author contributions. RWM provided input on the study design and outcomes, analysed the Vula referrals and wrote the first draft of the manuscript. TNM provided input on the study design and outcomes, analysed the study data and edited drafts of the manuscript. GdP assisted with analysis of the Vula referrals and reviewed drafts of the manuscript. JdT conceptualised the study, provided input on study design and outcomes, and edited drafts of the manuscript.

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Conflicts of interest. None of the authors are employed by Vula Mobile or received any financial benefit from this research or from use of the Vula app. Vula Mobile provided the dataset of referrals and responded to specific queries, but had no involvement in any other aspect of the study.

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