The cost effectiveness of early management of acute appendicitis underlies the importance of curative surgical services to a primary healthcare programme

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ABSTRACT

INTRODUCTION   Appendicitis in the developing world is a cause of significant preventable morbidity. This prospective study from a regional hospital in South Africa constructs a robust cost model that demonstrates the cost effectiveness of an efficient curative surgical service in a primary healthcare-orientated system.

METHODS   A prospective audit of all patients with acute appendicitis admitted to Edendale Hospital was undertaken from September 2010 to September 2011. A microcosting approach was used to construct a cost model based on the estimated cost of operative and perioperative interventions together with the associated hospital stay. For cost analysis, patients were divided into the following cohorts: uncomplicated appendicitis, complicated appendicitis with localised intra-abdominal sepsis, complicated appendicitis with generalised intra-abdominal sepsis, with and without intensive care unit admission.

RESULTS   Two hundred patients were operated on for acute appendicitis. Of these, 36% (71/200) had uncomplicated appendicitis and 57% (114/200) had perforation. Pathologies other than appendicitis were present in 8% (15/200) and these patients were excluded. Of the perforated appendices, 45% (51/114) had intra-abdominal contamination that was localised while 55% (63/114) generalised sepsis. The mean cost for each patient was: 6,578 ZAR (£566) for uncomplicated appendicitis; 14,791 ZAR (£1,272) for perforation with localised intra-abdominal sepsis and 34,773 ZAR (£2,990) for perforation with generalised intra-abdominal sepsis without intensive care admission. With intensive care admission it was 77,816 ZAR (£6,692). The total cost of managing acute appendicitis was 4,272,871 ZAR (£367,467). Almost 90% of this total cost was owing to advanced disease with abdominal sepsis and therefore potentially preventable.

CONCLUSIONS   Early uncomplicated appendicitis treated appropriately carries little morbidity and is relatively inexpensive to treat. As the pathology progresses, the cost rises exponentially. An efficient curative surgical service must be regarded as a cost effective component of a primary healthcare orientated system.

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Previously, it was reported that acute appendicitis was relatively uncommon in Southern Africa. More recent studies have suggested that the incidence of the disease in the region is increasing.[1–5] These studies also suggest that in Southern Africa, acute appendicitis presents late and is associated with significant morbidity.[1] In Southern Africa, the reported perforation rate of acute appendicitis ranges from 22% to 54%.[1–5] This is much higher than that reported in the developed world, which ranges from 14% to 22%.[1–5] This translates into considerable morbidity due to abdominal sepsis, which places a major burden on already limited resources.[6] The primary healthcare approach that has been advocated in the developing world emphasises preventative strategies rather than curative services.[7–10] However, acute appendicitis is not amenable to primary preventative strategies. Secondary prevention aims at limiting the complications of the disease process, and this depends on early recognition and early surgery.[11]

Traditionally, the public health approach has not focused on surgical services, which have been perceived as expensive curative services that benefit individuals rather than communities.[12] Despite this, there is a growing realisation that basic curative surgical care is an integral part of a comprehensive and efficient primary healthcare system.[7–9,15] The provision of appropriate curative surgical services should be an extremely cost-effective healthcare interven-

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Table 1 Cost formulas	
Cost of operation	Cost per minute (108 ZAR) x time (mins) x number of patients
Cost of analgesia	Cost per day (50 ZAR) x number of days x number of patients
Cost of antibiotics	
Amoxicillin/clavulanic acid	100 ZAR per day x number of days x number of patients
Gentamicin	60 ZAR per day x number of days x number of patients
Piperacillin/tazobactam	650 ZAR per day x number of days x number of patients
Fluconazole	750 ZAR per day x number of days x number of patients
Cost of hospital stay	
Cost of ICU stay	8,000 ZAR per day x mean number of days x number of patients
Cost of ward stay	1,245 ZAR per day x mean number of days x number of patients
Cost of hospital stay (ICU cases)	Cost of ICU stay + cost of ward stay

ICU = intensive care unit

tion in the management of acute appendicitis.[7,10] It would limit the morbidity associated with the disease in the region currently.[7] There is a paucity of published research focusing on the cost of acute appendicitis in developing countries. Our study from a regional hospital in South Africa attempts to construct a robust cost model of acute appendicitis with the intention of demonstrating the cost effectiveness of early surgical intervention in this disease compared with the cost of managing delayed advanced disease.

Methods

From September 2010 to September 2011, a prospective audit of acute appendicitis was undertaken at Edendale Hospital in Pietermaritzburg, South Africa. Patients were divided into two broad groups for analysis: uncomplicated non-perforated acute appendicitis and complicated acute appendicitis. Furthermore, the complicated appendicitis cohort was subdivided into those patients in whom perforation was associated with localised intra-abdominal contamination and those in whom it was associated with generalised four-quadrant soiling. Patients requiring intensive care unit (ICU) admission were analysed separately.

Four cost drivers were considered: cost of operative time, cost of analgesia, cost of antimicrobials and cost of hospital stay. A cost formula was constructed for each individual cost driver. Costs of consumables (antibiotics and analgesia) were obtained from the pharmacy manager, and cost of operating room and ward costs were obtained from the hospital financial manager. The sum of each individual cost drives was used to generate a total cost. The individual cost formulas are depicted in Table 1. The total cost was calculated by summation of all the individual costs.

Results

A total of 200 patients (128 male [64%], 72 female [36%]) were operated on for suspected acute appendicitis. The mean age was 22.8 years (median: 19.5 years). Of this group, 15 patients (8%) had pathologies other than appendicitis. These were excluded from our costing. Macroscopic inflammation of the appendix without perforation was found in 36% (71/200) and perforation in 57% (114/200). Of the perforated appendices, 45% (51/114) were associated with localised intra-abdominal contamination and 55% (63/114) had generalised four-quadrant soiling. The patients were divided into four groups for analysis: macroscopic inflammation without perforation (n=71), perforation with local contamination (n=51), perforation with four-quadrant contamination not requiring ICU admission (n=43), and perforation and four-quadrant contamination requiring ICU admission (n=20).

Strict antibiotic guidelines are enforced at our institution and these were used as a basis for our cost estimations. Patients with an inflamed appendix receive 24 hours of amoxicillin/clavulanic acid, a total of 3 doses of 1.2g each. Patients with perforated appendicitis receive 5 days of amoxicillin/clavulanic acid (1.2g 3 times per day for 5 days) together with gentamicin (240mg once daily for 5 days). Patients with four-quadrant sepsis who do not respond to the above regimen are converted to extended spectrum antibiotics (piperacillin/tazobactam) and an antifungal agent (fluconazole).

The cost of operating theatre time was 108 ZAR per minute. The cost of analgesia for an average patient was approximately 50 ZAR per day. For the uncomplicated group, the mean operating time was 30 minutes. All these patients received a mean of 24 hours of antibiotics and had a mean length of hospital stay of 2.5 days.

A total of 51 patients had perforation associated with localised intra-abdominal contamination. The mean operating time in this cohort was 60 minutes. All these patients received a mean of 5 days of antibiotics and the mean length of hospital stay was 5.8 days.

There were 63 patients with perforation associated with four-quadrant contamination. Twenty required ICU admission while forty-three were admitted to the general ward. The mean operating time required for each case was 90 minutes. Of the 43 patients who did not require ICU admission, the mean length of hospital stay was 9.5 days. In the cohort of 20 patients who required ICU admission, the mean length of stay in the ICU was 4.8 days. Following discharge from the ICU, the mean length of stay in the general ward was 12.9 days.

The total cost of antimicrobial therapy for the ICU was calculated based on the combination of agents used, with the mean duration of therapy derived from all patients in the group. The cost to stay in the ward was 1,245 ZAR per day and in the ICU it was 8,000 ZAR per day. The ICU daily cost included the use of the ventilator, oxygen therapy and sedation.

Table 2 summarises all the costs. The total cost for all 185 patients with acute appendicitis over the 12-month period was 4,272,871 ZAR. As severity of the illness increased, so costs increased exponentially (Fig 1).
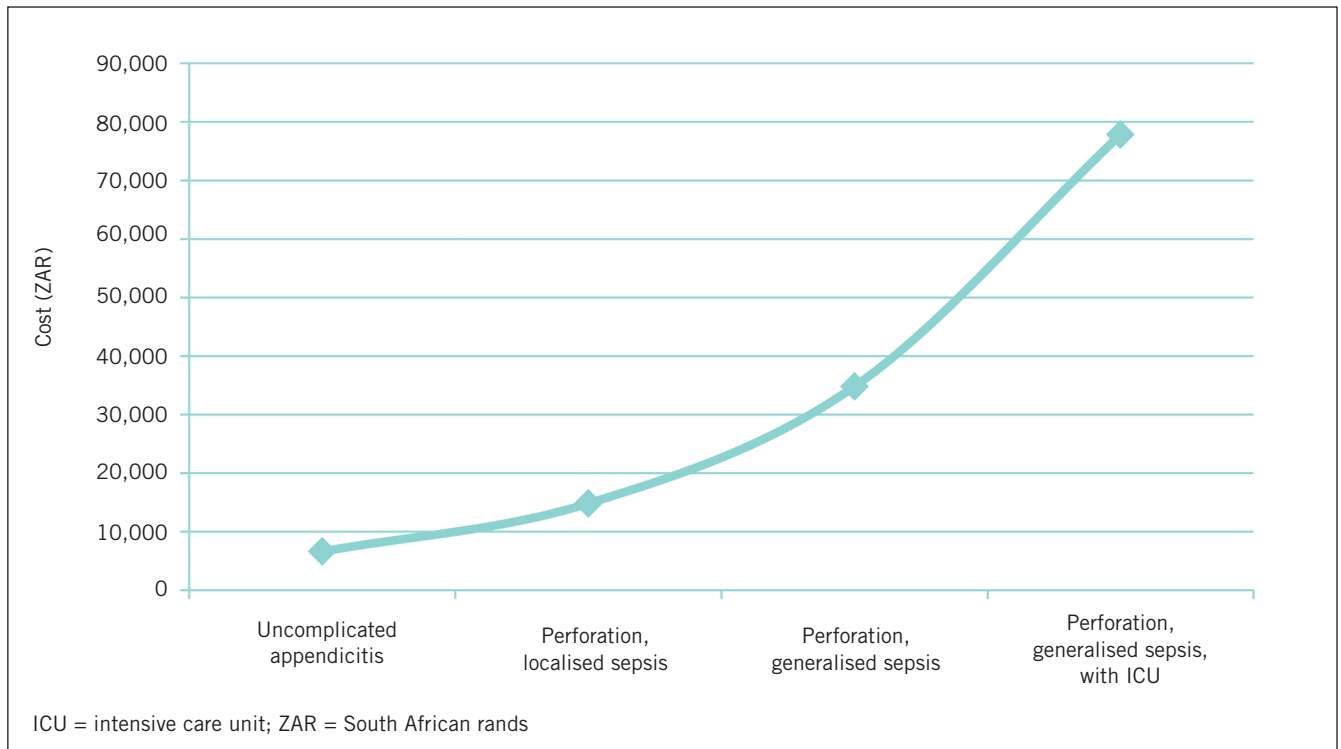
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ICU = intensive care unit; ZAR = South African rands

Figure 1 Cost per patient in South African rands for different patient cohorts

Table 2 Summary of costs					
Cost driver	**Uncomplicated appendicitis** (*n*=71)	**Perforation, localised sepsis** (*n*=51)	**Perforation, generalised sepsis** (*n*=43)	**Perforation, generalised sepsis, with ICU** (*n*=20)	**Total cost**
Operating time	230,040	330,480	417,960	194,400	**1,172,880**
Analgesia	8,875	14,790	20,425	17,700	**61,790**
Antibiotics	7,100	40,800	548,250	255,000	**851,150**
Hospital stay	220,988	368,271	508,583	1,089,210	**2,187,051**
Total cost	**467,003**	**754,341**	**1,495,218**	**1,556,310**	**4,272,871**
Mean cost for each patient (ZAR)	**6,578**	**14,791**	**34,773**	**77,816**	
Mean cost for each patient (GBP)*	**566**	**1,272**	**2,990**	**6,692**	
Mean cost for each patient (USD)*	**908**	**2,041**	**4,799**	**10,739**	

*Based on yearly average exchange rate in 2011: 1 ZAR = 0.086 GBP

**Based on yearly average exchange rate in 2011: 1 ZAR = 0.138 USD

Discussion

Acute appendicitis represents a significant workload for
the surgical services in our environment.[1,2,14,15] As in other
developing countries, a multitude of factors (eg health-
seeking behaviour, inadequate access to healthcare facili-
ties, failure to recognise and refer acute appendicitis and
logistical difficulties) conspire to cause delay, resulting in
significant morbidity.[1,16–18] Preventable morbidity translates
into significant consumption of already limited resources.[7–9]

While the primary prevention of acute appendicitis is not
possible, the secondary prevention of morbidity is poten-
tially achievable. Public health measures must focus on
ensuring adequate access to facilities capable of recognis-
ing and treating acute appendicitis and early operative in-
tervention.[19,20] It is important that secondary prevention of
the complications of acute appendicitis is prioritised.

Accurate costing is important for administrators and
policy makers.[21] The methods of estimating the direct cost

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of healthcare have traditionally been classified into two broad groups:[22–24] the bottom-up approach (microcosting) and the top-down approach (macrocosting). The bottom-up approach identifies and assesses the cost of each individual factor that contributes to the total cost to the healthcare system. The top-down approach uses global measures such as overall hospital stay to assign the total costs of a pathology to the healthcare system. This overall cost is then divided by the total number of patients treated to derive an estimate of average individual cost per patient. There are variations in the estimated cost using these different approaches.[25] In general, the bottom-up approach usually results in a higher but more accurate estimate.[26]

A study on the cost of orthopaedic trauma in KwaZulu Natal province compared the two methods and showed a difference of approximately 10%.[25] Other studies have demonstrated that the difference can be as high as 20%.[27] The bottom-up approach is more accurate because it allocates costs based on the actual consumption of specific resources, especially those relating to administrative and other services that support patient care. These represent a significant proportion of total direct costs.[27] In general, three types of costs need to be considered: direct costs, which include hospitalisation costs, physicians costs and medication costs; indirect costs, which are those borne by the patient (eg as time off work, time of travel and productivity losses); and opportunity costs.[28,29] An opportunity cost is the cost incurred because a limited resource is being used to treat a preventable pathology.[30,51] This resource cannot therefore be used to treat another deserving pathology.

Our study confined itself to assessing the direct costs of acute appendicitis and demonstrated that the total direct cost to the service was over four million ZAR. For a patient presenting with uncomplicated appendicitis, the total direct cost was 6,578 ZAR. In other words, for less than £600 the disease is cured, morbidity is negligible and the patients (who are usually young) experience minimal disruption and loss of income.[12]

Once the patient develops a perforation associated with localised intra-abdominal contamination, the direct cost doubles to 14,791 ZAR. Perforation with four-quadrant contamination that does not require ICU support sees a further doubling of direct costs to 34,773 ZAR. Once ICU support is required, the direct cost doubles again to 77,816 ZAR. This is over ten times that of an uncomplicated case. The treatment of advanced and complicated acute appendicitis accounted for 90% of the total expenditure. This implies that earlier recognition and treatment would have resulted in significant savings.

What was not considered in this study was the opportunity costs incurred in treating advanced disease, and the indirect costs borne by the patient and society in terms of lost economic activity. Consuming operating time and ICU resources for this preventable disease means that these resources cannot be used for the treatment of other pathologies. This costing is important as it shows the centrality of providing appropriate curative surgical services to a developing world health system. If secondary prevention fails, costs and morbidity rise exponentially.

Failure of secondary prevention of the complications of acute appendicitis results in major preventable cost and morbidity. In order to reduce cost and morbidity, the efforts of public health planners must be directed towards the secondary prevention of advanced abdominal sepsis. This involves a multifaceted approach that includes patient education programmes as well as efforts to increase access to healthcare facilities in rural areas and to improve the capacity of primary healthcare facilities in recognising acute appendicitis and to refer accordingly. There must be an improvement in the logistics to transfer these patients to surgical facilities.

An efficient and robust healthcare system is of the utmost importance if savings are to be achieved and morbidity is to be avoided. This costing provides convincing evidence to support the contention that efficient surgical services are a vital component of an integrated, comprehensive and cost-effective developing world healthcare service. Neglected benign surgical disease results in preventable morbidity as well as dramatically increased direct costs and opportunity costs.

Conclusions

Acute appendicitis is a common surgical pathology in our environment. If treated appropriately, early uncomplicated appendicitis has little morbidity and is relatively inexpensive to treat. As the pathology progresses from localised perforation to generalised perforation with sepsis, the cost of treating the disease rises exponentially. Improvements in so-called secondary prevention of this disease process will reduce morbidity and provide major cost savings. This study shows the importance and potential cost effectiveness of appropriate surgical services in a primary healthcare system. Without appropriate efficient surgical services, actual costs and preventable morbidity from this common disease escalate exponentially.

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