Part 1: Unnecessary surgical deaths

Introduction

The death of a mother

Sue Fawcus, an Emeritus Professor of Obstetrics and Gynaecology at the University of Cape Town is a doyen of obstetric outcomes. She left the United Kingdom in 1980 to arrive as a young medical officer during her obstetric speciality training doing outreach to rural district hospitals in Zimbabwe. She would later complete speciality training and ultimately become the Head of Obstetric Services at Mowbray Maternity Hospital, a large maternity hospital in Cape Town. She was the Deputy Chairperson of the National Committee for Confidential Enquiry into Maternal Deaths (CEMD) in South Africa, where she has spent a vast amount of time reviewing and analysing maternal deaths related to Caesarean section. She is quite literally a guru in this field. And a brilliant surgeon. Another eminent anaesthesia colleague tells me that if a mother is bleeding out, you want Sue. Sue is small in stature, steely in resolve, and extremely compassionate. I think that hard clinical exposure in trying conditions early in her career has forged this formidable character. She tells me of some of her early work in Masvingo in Zimbabwe in the late 1980s. A mother had previously delivered five children safely. She had been seen at an antenatal clinic, but considering her impressive obstetric history, it was considered appropriate for her to deliver at the district hospital, which was some 50 kilometres from a higher care obstetric facility. Her contractions started during the night but having no transport and concerned about leaving her children during the night, she decided to stay and deliver her baby at home. Unfortunately, she started to bleed. Her 11-year-old daughter quickly realised that her mother needed help. She left to ask the neighbours to inform the nearby clinic to send an ambulance. The little girl returned home to find her mother lying in pool of blood surrounded by her other younger children. She had succumbed to the bleeding.[1]

Bleeding is the commonest cause of maternal mortality.

A mother bleeds out

I stood at Janet's bedside. She was as white as a sheet. In my professional capacity as a specialist anaesthesiologist, I was comfortable with blood. When a patient starts to bleed out, my training allows me to relax and focus on what needs to be done. This time it was different. I wasn't the doctor, and this wasn't my patient, but rather the patient was a close friend. Janet's blood volume had drained out of her. The result, a cold, living person, so pale that she looked like a ghost. She was freezing with the blankets pulled up around her neck. Janet had that swollen, puffy look that follows pouring litres of clear resuscitation fluids into a patient's veins to keep the vessels open and carry the few remaining red blood cells around the body, to provide oxygen to the gasping, hypoxic cells. But thank God, Janet had made it.

Janet had been treated in a beautiful, modern private hospital in Durban, South Africa. The hospital was well resourced, with facilities and doctors who pretty much can and do carry out each and every surgical procedure known to man. Private healthcare in South Africa is astoundingly good. As a patient, you are surrounded by a hospital which looks more like a hotel than a hospital. It feels comfortable and smells clean. There is an air of competence, verging

on arrogance that is pervasive. As a patient it is comforting. For me, as a friend, I felt the relief of this palpable excess, when I saw Janet.

I knew it had must have been touch and go. I had been an anaesthesiologist for a few years, and I knew how quickly one can bleed out in childbirth, although, I never expected to know someone, who nearly did. Medicine is a small community in most African countries, and it wasn't surprising that I knew the anaesthesiologists who cared for Janet. They were good. Quite literally on the top of their game. In most operations a single anaesthesiologist will manage the care of a patient, no matter the severity of the surgical insult. It is really, in extraordinary situations, that a second anaesthesiologist is called for help. In her case, my colleague had fortunately, called a second colleague to help. It is likely, that these two exceptionally skilled anaesthesiologists, working in tandem, working in a well-resourced environment with a specialist obstetrician, and a dedicated theatre team are what saved Janet's life.

It must have been crazy for the surgical team. Janet had delivered a beautiful baby girl, but instead of the placenta obediently letting go of the lining of the womb, it stubbornly stuck, a condition known as placenta accreta. The placenta had grown into the muscle of the womb with no intention of ever letting go. This is rare, and stupid. The presence of the placenta in the womb, means that the bleeding will never stop, as the womb cannot contract down, which is necessary to compress and clamp the bleeding vessels that were once the lifeblood of the fetus. The result is that the mother's blood that passes through the uterus, just pours and pours out of the womb, instead of returning via the mother's veins to her heart for another trip around the body.

At term, about 10% of the mother's blood volume, 500ml per minute passes through the uterus. The blood is important as it provides the fetus with the necessary oxygen and nutrients. But, if the uterus cannot contract down and clamp the vessels, the result is a torrential flow of blood out of the severed veins of the placenta. At 500ml per minute, the mother will totally bleed out in under 10 minutes. This is postpartum haemorrhage, and it is terrifying. The problem is that we, the fantastic mammalian species of humans have fundamental flaws. If for some reason, the bleeding from the placental bed cannot be stemmed, then the blood accumulates and forms big clots inside the womb. It is not necessarily externally visible, but it is potentially terminal. The presence of the clots in the uterus, further hampers the uterus from contracting down completely. The vicious cycle continues as the torn veins following delivery remain open, and the obedient heart continues to pump blood to the uterus, which continues to leak more blood into its cavity. It is ultimately a death sentence without quick medical and surgical intervention. With the devastating volume of blood lost, the clotting factors which normally keep the bleeding in check, also pour into the uterus. The body now does not even have the capacity to form a clot to block the open veins.

Normally, a placenta would succumb to a gentle pull on the umbilical cord, and obediently follow the fetus out of the womb. It is these reticent placentae that kill. It requires skill and decisiveness to act with conviction. Janet had simply faded out of consciousness as the decreasing blood volume was simply insufficient to keep her brain alert. The surgeon knew that time was short, literally minutes before she would die, if the uterine arteries were not tied off imminently to stop the perfusion of the uterus and it's relentless bleeding. This would be followed by a hysterectomy, as the placenta had no intention of letting go, and the womb itself was now literally a fatigued muscle. The womb had completed a marathon, and was exhausted, and now was asked to give another Herculean effort to clamp down and stop the bleeding. This was never going to happen.

Janet's husband consented to a hysterectomy, while one of the anaesthesiologists put a tube into her airway to deliver oxygen, while the other secured large bore cannulae to pour fluids into her veins. It was precarious, but the synchronicity of an experienced team is evident at times like this. Everyone knows their role, and they work at breakneck speed. The surgeon moving decisively toward the offending uterine arteries to clamp them off so that no further blood will be spilled, and the anaesthesiologist providing oxygen, blood and fluids, and possibly a little bit of help to the heart, so that some nutrients can make their way around the body, to ensure that the heart, the head, the kidneys, and the other vulnerable organs don't suffer an irreversible injury or even worse death, before the bleeding is abated.

To save a mother, you need many skilled people, a decisiveness borne of expertise, supported by an experienced team and resources. A midwife, a theatre, a surgeon, an anaesthesiologist, a theatre sister, a floor nurse, a paediatrician, equipment, monitors, cannulae, lines, fluids, blood and drugs. And you need to access all of this within minutes, or it will be too late. I never expected that in my privileged social circumstance, where we have access to these resources, that a friend of mine might possibly die from bleeding following delivery. In less resourced environments, it is easy to see why mothers die nearly every two minutes. My wife and I had just had our first child, a beautiful boy, and now literally weeks later a friend of ours had had her first child, a beautiful girl, but had so nearly lost her life. She was saved by being in a well-resourced hospital, with an established team of healthcare professionals.

The fragility of our existence was only too evident, but in in poorer, less-resourced environments it is literally killing.

Personal experiences of a mother dying

The horrific nature of maternal deaths affects everyone who experiences them. Tinashe Chandauka is a Zimbabwean who studied medicine at the University of Cape Town, and then went on to Oxford to complete his DPhil. I was fortunate enough to meet Tinashe during his internship, during our first attempt to set up a national surgical plan for South Africa. He is wise beyond his years and has become an inspiration to me. He is committed to improving medical outcomes in Africa, and was convinced that part of this journey is through improving safety practices. This is his account in the introduction to his DPhil submission in Oxford on patient safety factors in the operating theatre;[2] "*My interest in safe obstetric surgery in South Africa began with the most humbling of events – a patient's death. As a medical student at the University of Cape Town, I took for granted that the world-class clinical medicine I was learning reflected how medicine functioned everywhere. I knew that severe resource constraints existed, but as a medical student I ultimately had no responsibility for the outcomes. I had no "skin in the game". However, my medical internship that followed in the Eastern Cape was a brutal introduction to medicine in a resource-limited environment marked by unpredictable deficiencies. Sometimes we had everything, then the next day we'd run out of drip needles. One summer morning, the obstetric surgery team in charge of the elective surgeries started the day with an emergency drill on post-partum haemorrhage. I remember it so well because I was sweating from resuscitating a doll so thoroughly that for a moment, I swear the pulse oximeter could actually measure some oxygen in its inanimate fingers. The humidity made the air thick and heavy. Our team went through all the steps: calling for help, the ABCs of resuscitation, establishing IV access, attaching monitors for mother and child, taking blood, giving drugs, reviewing progress and moving to increasingly invasive interventions to stop the bleeding. We debriefed and retired to the doctors' room before the*

first case began. That's when the shouting started. Two paramedics rushed an exhausted woman into the unit in a wheelchair. There was a commotion as they called out for help. Being veterans of the Eastern Cape, our obstetric team knew this could only mean a moribund patient was in urgent need of care. We took our places around her wheelchair, lifting her tired body onto a bed. I remember how she struggled to breathe and how cold and pale her hands were. This sort of thing stays with you, perhaps forever. While several doctors and nurses put into practice what we had just learnt in the drill, I heard the senior obstetric registrar (chief resident equivalent) ask the paramedics for her notes and clinical handover. They shook their heads. "Sorry doc," they said. "The midwives didn't give us notes. They are bringing them soon. They asked us to just bring her here as soon as possible… Apparently, she got worse all of a sudden and they called us." We were all shocked that they had left her notes, but we had to proceed with the resuscitation. Within fifteen minutes our patient, Ms X, had IV access, blood ordered and was delivering her child in the labour ward. Ms X was so fatigued she could not apply any effort to push her baby, and we had to use forceps to assist her. She delivered a floppy child who was rushed to the neonatal ICU next door. But Ms X kept on bleeding. The obstetric registrars and consultant battled to find the source of bleeding and resorted to using a balloon tamponade to stop the haemorrhage. Oxytocin simply wouldn't work. A decision was made to operate and the team prepared Ms X for theatre. We gave her blood, took blood gases and kept resuscitating her. When she lost consciousness, we intubated her and took her to theatre. We knew we could still save her life by arresting the haemorrhage. An anaesthetic registrar attempted to place an arterial line to measure blood pressure. Minutes turned into tens of minutes until her consultant was called. In the red mist of clinical combat, the trainee had become fixated on the arterial line. Once the consultant arrived, the trainee could focus on the rest of the induction. Unfortunately, Ms X developed cardiac arrest and despite an hour long on-table CPR, she died. Our team was devastated and shocked. As we reeled from the shock, a nurse from the community delivery facility that had referred her arrived with her notes. A diligent night shift student nurse had charted her prolonged labour and even marked with red ink on the partogram the points where Ms X crossed the alarm lines. It was not clear why no action was taken. Ms X was overweight, but other than that she had no underlying condition. The loss of her life was acutely felt by the district service. The maternal morbidity and mortality audit concluded that her death was preventable, and that it was the result of several system and human factors errors lining up. I went to bed that night knowing that I needed to use my doctoral degree at Oxford to do something about this."

Sadly, death after childbirth is not uncommon. Compared to the nearly 13 000 people who died in Africa from Ebola since 1976,[3] between 2014 and 2017 there were in excess of 190 000 maternal deaths in Africa annually, or 778 000 deaths over those four years.[4] Globally, about 300 000 women died ever year during this period, or a total of nearly 1 ¼ million deaths over the four year period. A mother died following childbirth every 1¾ minutes, 24 hours a day, 365 days a year during this period.

Why did these mothers die? And what was different that my friend survived massive haemorrhage? Are these deaths following caesarean deliveries symptomatic of a larger societal health problem related to surgical care? Can we save mothers with simple healthcare strategies? Will the existing deficiencies in surgical care which may have resulted in the deaths of these young mothers potentially impact on my family and I in our privileged position?

I hope to answer these questions in this book by introducing you to the work of colleagues, who have been touched by these personal experiences of death and have worked towards providing surgical (and more broadly health) equity for all.

Mothers dying

Maternal deaths over time

To start to answer these questions, one must go back to the beginning of tracking deaths. It was the Swedish clergy who started recording all the births and deaths within their parishes as far back as 1749, which very quickly led to the registration of the entire Swedish population.[5] This morphed into a national database or *Tabellverket* where the Registrar-General started tracking national mortality statistics.[6] As early as 1751 maternal deaths were being recorded, accurately, reliably and uninterrupted, and have been ever since in Sweden.[5]

Counting maternal deaths has demonstrated the tremendous progress we have made in maternal health. In Sweden, in the 230 years between 1750 and 1980, maternal mortality fell a 150-fold, with two-thirds of the improvement seen in the 18th and 19th centuries. Death registrations started later in England (1837),[5] and maternal mortality statistics were included from 1857 onwards,[6] although the improvement in the United Kingdom was not quite as impressive as in Sweden.

Part of the success in maternal outcomes reflects an improving social status over time which confers a survival advantage and a clear determinant of health.[7] It has resulted in a tumbling infant mortality, and maternal mortality. The real benefit of social status is seen within the aristocracy, the beneficiaries of the ultimate social status. It certainly was not a '*misfortune to be a great ladie*', as fewer than 5% of all aristocratic mothers died in childbirth between 1558 and 1959.[8] Indeed it was more dangerous to be married to Henry the Eighth than to bear his child. It is incredible to think that Queen Victoria had nine children, and she survived.

Tracking the maternal mortality in England and Wales showed the improvement in the maternal mortality rate as society progressed through the 1800s, but then in started to slow, plateauing between 1880 and 1930.[5 9] Maternal mortality was still running at a horrifying 500 deaths per 100 000 births during this period.[9] Although, the improving quality of care had resulted in a reduction of haemorrhagic maternal deaths in England and Wales, with a 56% reduction in haemorrhagic deaths between 1874 and 1926, there was no real reduction in overall maternal mortality. This was because of the increasing problem of sepsis associated with delivery, driven by a lack of antibiotics at the time.[10]

Tracking maternal deaths nationally resulted in some pivotal moments in improving maternal outcomes. At the simplest level, by counting the deaths it was possible to identify the poorly performing areas. By the early 1930s, the maternal mortality rate ran at 460/100 000 in the United Kingdom,[5] although it varied tremendously across the country. An industrial town in northwest of England, Rochdale in the greater Manchester area, stuck out like a sore thumb. It was a textile powerhouse with navigable canals ensuring access to the sea trade routes. While it was an industrial star, it simultaneously had the unenviable distinction of having the highest maternal mortality in England, with 900 deaths per 100 000 births, nearly double the national average.[11] Andrew Topping, the newly appointed Medical Officer of Health in Rochdale was clearly unhappy with the status quo, and described the obstetric conduct of some general practitioners as '*a little short of murder*'.[11] He was well aware of the slight Rochdale had on the medicine and obstetrics in England, and importantly its negative reflection on his position. He responded with an obstetric quality improvement project, which became known as the 'Rochdale experiment'. Between 1930 and 1935 the impact of his project to improve the standard of obstetric care was a resounding success as demonstrated by a maternal mortality

which fell from 900 to 170 per 100 000, and then held steady and was sustained.[11] While improving social status is often a confounder in better health outcomes over time (famously demonstrated by Sir Michael Marmot),[7] the brilliance of Andrew Topping's 'Rochdale experiment' was that the social status did not really change in Rochdale during this period demonstrating the massive beneficial effect of improving the quality of obstetric care on maternal mortality, even in an environment which many had considered hopeless. Indeed, these were not 'fancy' interventions, but rather the 'experiment' demonstrated that 'an ordinary standard of good obstetric practice, not necessarily at the level of the hospital specialist, can be expected to have a *profoundly* beneficial effect in societies that still suffer high maternal mortality.'[11] The 'Rochdale experiment' had demonstrated an 80% relative risk reduction (RRR) in maternal mortality in a five year period. This impact on maternal mortality can only be dreamt of today. The intervention delivered in the 'Rochdale experiment' had focused on improving the quality of maternal care provided by birth attendants.[9] Andrew Topping's simple, yet appropriate world view of health, was later recognised when he went on to became Dean of the School of Hygiene and Tropical Medicine in London in 1950, famous for its global public health initiatives and leadership.

Andrew Topping's intervention with a RRR of 80% is simply remarkable. The RRR provides data on the efficacy of an intervention. A RRR of 80% is closer to the realm of primary prevention interventions. For primary prevention, such as vaccine immunisation programmes, the RRR for mortality is huge, and often well over 90%. This means we can almost certainly prevent death. And this is what we saw with the roll out of vaccinations for Covid-19. Essentially, most vaccines are absolute life savers. However, once you get into the messy world of clinical medicine, the number of factors impacting on a patient's outcome are many. So, a mother who is bleeding after surgery, could die as a result of a number of reasons. A delay in treating bleeding may result in irreversible changes to coagulation, and torrential bleeding, or the mother may die because blood or the blood products needed to treat the mother were not available, or the surgeon was busy with another operation and the mother died before she could get to surgery, or she got to surgery but died on induction of anaesthesia as she had already bled out too much, or she could have had a great operation but continued to bleed slowly into the abdomen and slowly drifted out of consciousness and died 'in her sleep'. There is a myriad of factors which can result in a mother dying. And for this reason, most interventions nowadays have a much lower chance of decreasing maternal mortality on their own. The result is that in clinical medicine the RRR associated with an intervention for mortality is much lower, as there are so many processes which may ultimately kill a patient. Realistically, in clinical medicine we now get excited when an intervention has a RRR of 30% in these environments. That means that if we have an effective intervention, it is likely to only save about one in three from death, because in the other two cases our attempts will be thwarted by other unrelated contributors to death in the pathway to mortality.

It is possible that quality improvement interventions have the potential for slightly higher RRR as shown in the 'Rochdale experiment' if they simultaneously and successfully address more than one potential pathway to mortality. This is appropriately demonstrated in the World Maternal Antifibrinolytic or WOMAN trial. Here a drug was given that prevents the breakdown of early clots, known as tranexamic acid, and so prevents ongoing bleeding. This was a large trial in women who bled following delivery. Death due to bleeding was significantly reduced in the patients that received the tranexamic acid. Death due to bleeding fell from 1.9% to 1.5%, or a 19% RRR (with a 95% confidence interval (CI) of zero (no benefit) to a 35% RRR reduction in bleeding).[12] While the study shows a 19% RRR, the CI demonstrates the spread of certainty for the actual efficacy of the intervention. Basically, the absolute best efficacy for

this intervention is a RRR of 35%, and the best estimate of efficacy (which is the trial result) is just under 20%. Although most would agree that giving tranexamic acid is essential in a woman who is bleeding post-delivery, this is not a panacea because the impact of a single intervention (such as giving tranexamic acid on clot stability) on the outcome of bleeding is potentially far more limited, than a number of quality improvement initiatives addressing various factors associated with mortality, such as was done in the 'Rochdale experiment'. A woman who is bleeding after a caesarean delivery needs a functional healthcare system to ensure that she gets timeous, and appropriate care to stem the flow of blood. The principle is that in low quality healthcare systems, we are likely to get a better return on improving outcomes when we have many interventions that work across many parts of a dysfunctional system. Giving tranexamic acid alone may save a mother, but if one is unable to provide the supporting surgical care necessary to remove the remaining placental products from the uterus so that it can contract down, or even more dramatically to remove the uterus to halt bleeding if the uterus is too tired to contact, many more mothers will die because of these limitations. In high-quality healthcare systems, where the many parts of the system are functional, people spend more time looking for new single interventions to nudge towards further improved patient outcomes, but in contrast, in low-quality healthcare systems we need to pay attention to the entire healthcare system if we want to improve patient outcomes.

Another famous example of the impact of improving quality of care in a complex environment by multiple interventions is Florence Nightingale's work in the Crimean War between 1854 and 1856. This too resulted in an unbelievably high RRR for mortality in a complex environment. She was a nursing pioneer, a data tracker and 'statistician' of note. The British soldiers from the Crimean front travelled across the Black Sea to Scutari Hospital, near Constantinople in Turkey, where Florence Nightingale was working with a team of 40 other voluntary nurses. In February of 1855, 43% of the arriving soldiers died in the hospital. Florence was convinced that there were five factors contributing to these deaths: overcrowding, poor ventilation, sewerage, a lack of cleanliness and hospital comforts. From her previous nursing experience in London, she calculated that the patients in Scutari had about a ¼ of the space of patients in London hospitals. While she could not change the overcrowding, Florence and her team set about addressing the other four factors in March 1855; they opened the windows, removed the rubbish, buried the dead animals, flushed the sewers, washed the clothing, and provided eating utensils. By June, a mere three months later, the mortality had fallen to 2%.[13] This was a 95% RRR for mortality. A massive reduction, produced by the power of simple, generalisable interventions which tackled multiple quality of care issues head on. These interventions had positively affected multiple potential pathways to death simultaneously.

With such a massive swing in mortality, the Principal Medical Officer of the Army could not accept that this was the result of Florence and her team of nurses. He claimed that it was due to the condition in which the soldiers had arrived, and not the work of Florence and her team. But Florence was a genius, and a force to be reckoned with. To rebut the Principal Medical Officer, she chose two groups to demonstrate a worst- and best-case comparison to Scutari Hospital. The worst-case scenario was that the soldiers who were too sick to be moved to Scutari. Scutari at its worst had a mortality of 43% before Florence's interventions, but the soldiers at the battle front who were considered 'too far gone' to survive the boat trip to Scutari, were fortunate that they were not sent to Scutari, as their mortality was only 27%, nearly half that of the patients who received care at Scutari. To compare the best outcomes seen by June 1855 in Scutari, she compared the outcomes to the desirable London hospitals. The mortality in these London hospitals was astonishingly higher than that in Scutari.[14] Florence Nightingale

used numbers to support her case, just like the Swedish clergy had used numbers to track their parishioners.[14] Florence showed a link between the sanitary interventions and mortality in the languishing soldiers. She had decreased the exposure to many pathogens on various surfaces across the ward with astonishing success. She tracked the outcomes in circular pie charts that she had developed, known as Coxcomb charts. Florence was providing real time feedback on the success of the interventions to her team. She had her finger on the pulse of mortality in Scutari Hospital, and she could respond timeously as a result. Her inspirational leadership inspired her team to continue its impressive work.

Just like Florence, who almost certainly decreased exposure to the pathogens causing sepsis, getting on top of sepsis was to result in another period of success in improving maternal mortality across England and Wales when it tumbled by 85% between 1932 and 1952, which had previously been limiting the reduction in maternal mortality between 1880 and 1930. The contribution of bleeding to maternal mortality also fell during this period due to the introduction of drugs to contract the uterus down, and blood transfusions. There was now a swing from sepsis been the main driver of maternal mortality[10] to a realisation of the importance of bleeding in maternal mortality. This was identified by the introduction of the Confidential Enquiry into Maternal Deaths (CEMD) in the 1950s in the United Kingdom which identified the retained placenta after delivery as of the drivers of haemorrhagic deaths.[10]

While Florence Nightingale started to improve mortality by improving the quality of care delivered in her wards, another nurse across the Atlantic was immortalised by taking care to the patient. Clara Barton demonstrated that by ensuring early access to care, it was possible to decrease mortality. Her work started with taking horse drawn 'ambulances' to soldiers in the battlefield during the American Civil War in the 1860s. Later she would go on to establish the American Red Cross.

In the early 1950s in Cape Town, South Africa, mothers were also receiving care too late. Mothers had little access to care and were dying at home. So, care was taken to the mothers with the introduction of the 'flying squads.' Just as Clara Barton had improved the outcomes of soldiers at the battlefront by getting care to them early, the obstetric 'flying squads' also decreased maternal mortality by taking early obstetric care to the mothers in their homes.[15] The principle of the 'flying squad' was to take the care to the mothers, when they could not access obstetric care timeously. Just as the UK CEMD had identified the 'retained placenta' as a major driver of maternal mortality in early 1950, so too in the Western Cape there was an appreciation that '*the beds available for routine and emergency obstetric care (were) grossly inadequate and a large proportion of the population (was) not aware of the advantages of competent ante-partum and intra-partum care, which, moreover, (was) not always attainable*'.[16] The reasons given for the 'flying squads' are as relevant today in low resource environments as they were 70 years ago in Cape Town. If you want to get a feel for what it was like to be part of the 'flying squad' at that time, a visit to the District Six Museum 'flying squads' display is excellent. Proud midwives in their starched uniforms standing next to their shiny green short wheelbase Land Rovers. My mother had been a midwife who was part of the obstetric 'flying squad'. She tells me of how she would arrive with a doctor and enter a single dark, smoked filled room with the walls covered in soot, to find a mother lying on a kitchen table in a pool of blood. If that is how the mothers looked at home, we can understand why they had little chance of survival if they still needed to find their way to the hospital for treatment. It is unsurprising that the impact of the 'flying squads' was huge. In the first 33 months following their introduction in September 1953, there were 192 calls, of which 165 (86%) were for postpartum haemorrhage (classic retained placenta stuff, the same killer as in the 1952 UK CEMD), with six deaths (3.1%) in

total.[16] All the mothers that died, had died from haemorrhage. Three were dead on arrival, and the other three died within 15 minutes of the arrival of the obstetric 'flying squad' team.[16] Those six mothers had literally no chance, as most of their blood volume had already bled out through the open vessels of the uterus, just like the lady who died at home in Masvingo, Zimbabwe. The success of the 'flying squad' was tangible, as shown by the amazing fall in maternal mortality in Cape Town following its introduction, with a nearly 80% RRR in maternal mortality between 1953 and 1959 (Table 1).[17]

Table 1. Maternal mortality in Cape Town following the introduction of the 'flying squad' in 1953

Year	Maternal mortality rate/ 100 000 deliveries
1953	301
1954-1956	199
1957-1959	66

Increasing 'access' to care by taking midwifery care to the mother had a massive impact on maternal outcomes. The increase in access decreased 'failure-to-rescue', and the good midwifery services improved the quality of care given.

Sadly, the maternal mortality in Cape Town in the 1950s and in Rochdale in 1937 is lower than the present day maternal mortality in sub-Saharan Africa, which currently runs at 546 deaths per 100 000 live births.[18] This is equivalent to the United Kingdom in 1900, or Sweden in 1880. Increasing both access to care, and the quality of care is likely to have a massive impact on maternal mortality in Sub-Saharan Africa.

Caesarean deliveries and the 'inverse care' law

Sue Fawcus' first caesarean section in a district hospital in Zimbabwe was for cephalopelvic disproportion (basically the baby was not going to make it out of the pelvis vaginally, as the head was too big for the pelvic outlet), and the mother therefore required a caesarean section. At about midnight after the porter had fetched the patient, he waded across the river to turn on the generator to power up the operating theatre for the operation. A final year medical student proceeded with the spinal anaesthetic, and then donated some of her O-positive blood, as the mother's haemoglobin was already low. The medical student was not only the anaesthetist, and the blood donor, but she was also the 'paediatrician' and quickly moved round to 'catch' the baby after it was delivered by Sue, so that she could dry, warm and stimulate the newborn to breathe. This mother and child had faced many hazards, but fortunately both made it through unscathed. No dedicated anaesthesia or paediatric care, amongst numerous other risks including potential blood reactions and a relatively inexperienced medical team. In most district hospitals at the time, the same doctor administered the spinal anaesthetic and then went on to perform the surgery with the patient's vital signs and anaesthesia being monitored by an experienced nurse.

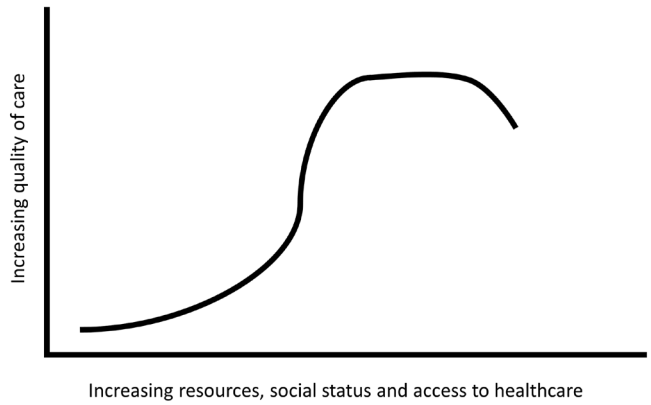
In resource-limited environments, healthcare workers at the coal face are continually balancing risks. Here, Sue had a mother and child who needed a caesarean section. An unnecessary delay could have resulted in the death of both the mother and child. So, the caesarean section had to be done in an environment which was far from ideal. An anaemic patient, a young doctor in training for obstetric specialisation, with a medical student conducting the anaesthetic and the neonatal resuscitation with no back up expertise for either. The alternative was an unforgiving road trip to the hospital in Harare, predominantly dirt with only a little bit of tar towards the

end of the journey. Easily five hours of difficult travelling. Five hours was too long. Sue was battling the perennial problem in resource-poor environments, of limited and difficult access to an appropriate level care, at a time when the patient needs were most acute.[19] This is hardly the ideal environment to provide quality care.

We have seen that increasing the access and quality of care improves outcomes. Now, reflecting on 40 years in obstetric care and confidential enquiries into maternal deaths, Sue reflects passionately on the truth of the 'inverse care law'.[20] Tudor Hart wrote 50 years ago that "*the availability of good medical care tends to vary with the need for it in the population served*."[20] Stated in another way; "*disadvantaged populations need more health care than advantaged populations, but receive less*."[21] This is the 'inverse care law'. This is the dilemma that Sue faced in her early days as a young doctor in Zimbabwe and a scenario that she has subsequently seen play out countless times when reviewing maternal mortality across her career. When one now asks Sue to explain her understanding of maternal outcomes, she states it clearly around the principles of the 'inverse care law'; "*skilled personnel are concentrated in urban areas doing unnecessary caesarean sections in low-risk women, whereas poor women in rural settings have necessary caesarean sections performed too late because of poverty and barriers to access, which are performed by less skilled personnel, and patients die. Reading through cases of women who die from bleeding at caesarean section is tear jerking because the majority need not have died*." The 'inverse care law' is primarily about the inequity (and injustice) in health care that results in the unfair social inequalities in health.[21]

The 'inverse care law' was already prevalent in maternal health in the 1930s in the UK and Sweden. In fact, the over-servicing of the 'high society' was so excessive, that while one would have expected the maternal mortality to continue to fall, it didn't in the 1930s (because of a lack of antibiotics at the time). The increased access to maternal care in the wealthy, resulted in many inappropriate and unnecessary obstetric interventions which resulted in septic complications when effective antibiotic treatment was not yet available.[5] With the over-servicing, the wealthy in the UK did realise some of the benefits of better obstetric management, with plummeting haemorrhagic deaths.[10] The 'inverse care law' is shown in Figure 1. Those with the least means, get the least care. But as social status and available resources improve, so does the care until the care plateaus at a high level. In extreme circumstances of over-servicing, this results in unnecessary harm, seen as the 'tail off' on the right of the graph. In the 1930s in the UK, it was due to sepsis following unnecessary obstetric interventions. One may expect that we may see the same with unnecessary caesarean sections in the 'too posh to push' society of today.

Figure 1. The 'inverse care law'



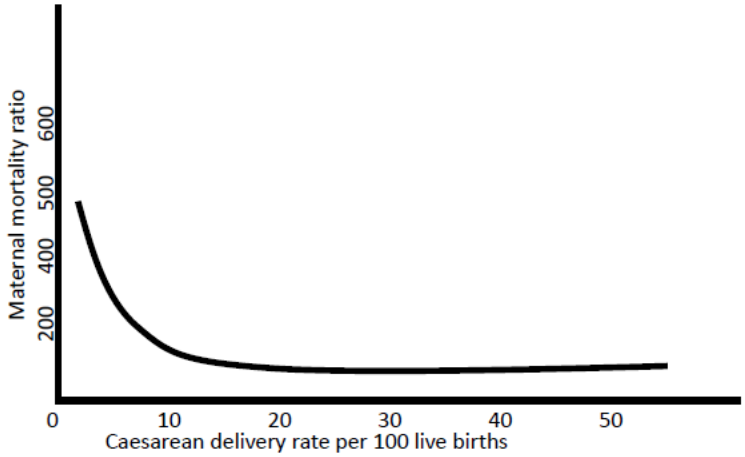
Nowadays, recognition of aseptic techniques in labour, prevention of prolonged labour and antibiotics have decreased septic deaths following caesarean sections, leaving haemorrhage as the leading cause of maternal mortality globally, with nearly 45 000 deaths in 2013,[22] or one woman dying every 12 minutes from maternal haemorrhage. While haemorrhage is one of the leading causes of death in high income countries, it *is* the leading cause of death in low-resource environments,[23] and it is also the leading cause of mortality following caesarean section in Africa, contributing to nearly half of all the maternal deaths.[24]

Surgery is one of the therapeutic interventions to stop ongoing haemorrhage following vaginal delivery and caesarean section, including hysterectomy as a last-ditch attempt. When one considers the proportional contribution of vaginal and operative deliveries to haemorrhagic deaths in mothers, the South African Saving Mothers report for 2008-2010 reports that bleeding associated with vaginal delivery was responsible for nearly ¾ of the haemorrhagic maternal deaths.[23] As hysterectomy is often a solution to torrential haemorrhage following childbirth (as in Janet's case), then why were there not more surgeries following vaginal deliveries associated with massive haemorrhage? The answer is linked to an inability to provide access to surgical care in these patients.

For the mothers who had caesarean deliveries, the contributing factors to deaths associated with bleeding are enlightening; poor control of bleeding at the time of the initial caesarean section, a lack of the surgical skill necessary to stop the bleeding, and poor post-caesarean section monitoring.[23] These are factors dependent on the quality of the surgical care. To save mothers who are bleeding, you need to identify the risk for bleeding, be able to intervene appropriately and timeously when there is bleeding through non-surgical interventions (such as removal of the placenta, drugs, uterine massage, and blood) and you need the ability to provide the surgical control of the bleeding if it is needed. Surgical interventions may include removal of remaining placental parts from the uterus, ligation of the uterine arteries feeding the uterus, and hysterectomy. The poor control of bleeding at the time of the caesarean section, and the lack of surgical skills, suggest limited training and practical surgical experience.

Tracking volume of caesarean sections performed in a population provides an important insight into the twin requirements of the minimum practical experience necessary for quality care, and the appropriate access to surgical obstetric care, necessary for safe maternal care. The sweet spot is about 19 caesarean sections per 100 live deliveries. If one cannot provide at least this number of caesarean sections then maternal mortality increases (Figure 2).[25] In Africa, we cannot provide this number of caesarean sections per 100 live deliveries. In fact, we provide about a quarter of that, at five caesarean sections per 100 live deliveries. This low number of caesarean sections reflects the combined problems of insufficient access to surgical maternal care, insufficient resources to deliver quality surgical care and insufficient surgery to ensure the skills necessary to deliver quality surgical care.

Figure 2. The relationship between maternal mortality and caesarean section rate in 2013



Just as maternal mortality increases with decreasing access to caesarean sections, so too does neonatal mortality increase. This is the situation for most of Africa.[26] Limited access to caesarean sections results in women dying unnecessarily at home, as happened to the mother in Masvingo, or are operated upon by teams with limited skills and insufficient practical exposure, such as Sue's first caesarean section outside Harare. Literally every operation is a risk, with unnecessary deaths on the table. And it shouldn't have to be like this. Surgery is a key component of maternal health. If at least 19 caesarean deliveries are required per 100 live births to maximise maternal and neonatal health, then it is reasonable to suggest that surgery accounts for at least 19% of maternal obstetric health. Unfortunately poor maternal outcomes increase exponentially as access to surgery is curtailed. For example in 2013, countries which were able to provide between 19 and 27 caesarean sections per 100 live births, had a maternal mortality rate of 36 per 100 000 live births, compared to countries which could only provide 7 to 19 caesarean sections per 100 000 live births where the maternal mortality was nearly four times higher at 137 per 100 000 live births, and countries providing <7 caesarean sections per 100 live births had a maternal mortality rate of 463.[25] Therefore, decreasing access to surgical obstetric care is not associated with a linear increase in risk, but rather an exponential increase in maternal mortality, as shown in figure 2. This is the result of compounding a lack of access to surgical care, which results in predominantly emergency caesarean deliveries provided by surgical teams with inadequate surgical exposure or insufficient resources necessary to deliver quality surgical care. And these simple demonstrations of lost lives do not even consider the massive impact of losing a mother and young adult on a family, the broader community and a country.[27] Indeed the proportional contribution of surgery to maternal health therefore probably far exceeds 19%.

Although tracking maternal mortality is grim, it has the power to identify areas of need, and the impact of access and quality of care on outcomes. Tracking maternal mortality has allowed us to understand the non-surgical and surgical contributions to maternal and neonatal health. Tracking maternal mortality, allowed Andrew Topping to demonstrate the powerful effect of the quality of care on maternal outcomes in Rochdale, and it allowed the Cape Town 'flying squad' to improve maternal outcomes by increasing assess to early care. Tracking maternal mortality has also allowed us to understand the need for a minimum number of surgical deliveries to ensure that the entire obstetric package of care is sufficient to keep mothers safe and optimise the outcomes for both mother and child.

Surgery in Africa

The excess deaths following surgery in Africa

Surgery is however far more than caesarean deliveries alone. It is about comprehensive care across medical disciplines. However, any surgery is about balancing risk and benefit. Surgery is indicated when the net surgical benefit exceeds the risk to the patient. But, surgery does carry risk, and that risk includes death. The worst-case scenario would be a 100% mortality associated with surgery. That is every patient that has surgery dies. Unbelievably, in the history of surgery there was an English surgeon in the 1840s who sadly has the infamy of a 300% mortality for an operation. John Liston amputated a leg with such haste (as anaesthesia and analgesia where yet to feature in surgical care), that he cut through his surgical assistant's fingers at the same time. Both the patient and the assistant died from surgical site sepsis (which incidentally remains the leading killer following non-obstetric surgeries to this day), but simultaneously a spectator of the operation, collapsed and died after witnessing the ordeal.[28] Fortunately, surgery is now extremely safe. Over the last century perioperative mortality has decreased over a 100-fold. In Europe, in-hospital mortality runs at an average of 3% following all elective surgeries.[29] This may sound high, but that includes all the really big cancer surgeries, where without surgery the majority of patients would almost certainly die. Unfortunately, these surgical benefits are not available to all.

Rupert Pearse is the lead intensivist at Queen Mary's University, London. He shot to fame in 2012 after leading the European Surgical Outcomes Study (EuSOS). It was a snapshot study of in-hospital mortality following surgery across Europe.[29] It led to some controversy, as after risk adjustment it appeared that when compared to the UK, patients were more than twice as likely to die following surgery in Ireland and about five times more likely to die in Latvia. It is unlikely that this is actually the case (but that is another issue based on numbers and sampling), but rather the important point was that surgical outcomes varied across countries, and your surgical destiny (and mortality) could be determined merely by your place of residence. I had the good fortune of hearing Rupert present the study in London in 2012 and was struck by the study's simplicity. Being a nerd, I wanted to replicate the study in South Africa to understand our surgical outcomes. Rupert willingly shared all his study materials, and resources, and we conducted the study successfully in South Africa.[30]

Almost at the same time that our South African work was published in 2015, the Lancet Commission for Global Surgery was released.[31] It was a carrion call for increasing safe surgical and anaesthesia care necessary to support global health equity. Global indicators of surgical performance were proposed to ensure that 80% of the global population would have access to safe and affordable surgery by 2030. These included access to surgery, volume of operations, the workforce constitution, tracking mortality (naturally!) and the financial burden of accessing surgical care. We knew from Rupert's work in Europe and ours in South Africa, that these indicators were not readily available, so it was difficult to know what surgery was happening, and what the surgical outcomes were across the globe. It was fortuitous, but we were primed to respond to the call by the Lancet Commission. We established a continental study known as the African Surgical Outcomes Study (ASOS) to document the current state of surgery in Africa. We adopted the existing study model that Rupert had developed to document global surgical outcomes[32] which would allow for global comparisons with the African data.

The ASOS data were distressing to say the least. From the nearly 250 hospitals in 25 countries across Africa, each hospital conducted on average only 29 operations per week, while each

hospital was serving a population of nearly a million people, with less than 1 specialist per 100 000 population delivering this service. With such a limited surgical system in Africa to support such a vast population, it was unsurprisingly that the mortality following surgery in Africa was twice the global average.[33]

The findings of ASOS challenge us to address the drivers behind the deaths of mothers in Africa, and more broadly, of all the surgical patients in Africa.

The lack of health equity in Africa

When one considers global health which is well documented in the 'Our world in data' website (https://ourworldindata.org/health-meta), we see that life expectancy is increasing, and child and maternal mortality are falling across all countries. The relative difference in health outcomes between countries is also falling, which means that society is moving towards greater health equality. The clarity of the progress made in health is well described in Steven Pinker's book 'Enlightenment now'.[34] However, we must not be fooled. Although all graphs show decreasing gaps between income groups, the reality is that we are still a long way from population health equality, especially if you consider that the mortality following caesarean delivery in Africa is 50 times higher than that of high-income countries.[24]

The real issue about health however is not about equality, but rather about equity. Equality speaks to individuals or groups of people having access to the same opportunities. We could consider the increase in life expectancy and fall in mortality as increasing equality. However, this is not equity. Health equity recognizes that each person despite their different circumstances, has the resources and opportunities needed to reach an equal outcome.[35] While equality is increasing, equity is certainly not. Africa for example is the region with the lowest global health workforce at the nursing and midwifery level, and at a physician level, with 12.4 and 2.7 per 10 000 population respectively.[36] Compare this to the global nursing and midwifery, and physician ratios of 28.6, and 13.9 respectively.[36] Africa's nurses and midwifes are less than half of the global average, and physicians are less than a 1/5. And the resources available are insufficient to treat all the patients, while some resources are completely absent, negating some surgical therapeutic options completely. This is inequity.

While mortality and life expectancy numbers may demonstrate increasing equality, I will demonstrate with surgical examples, how they hide the disparate inequity in health, and in particular, surgical care which is compromising the health of the entire population in less resourced environments. This is because surgery is required to ensure complete health coverage across all disease categories: that is maternal and child health, noncommunicable and communicable diseases and trauma. I will demonstrate why there is a need for more and better surgical care in Africa (and other low and middle-income countries) if we are to advance towards health equity. The foundations are to be found in the Lancet Commission for Global Surgery recommendations for safe surgery[31] which include; i) access to timely surgery, which is a facility that can conduct a caesarean section, a laparotomy and manage an open fracture within 2 hours, ii) a specialist workforce of at least 20 specialists per 100 000 population, iii) the ability to conduct at least 5000 surgical procedures per 100 000 population, and iv) protection against impoverishing and catastrophic expenditure through out of pocket expenditure necessary for surgical care.

Too little surgery

It is only through the COVID-19 pandemic that the problem of too little surgery become a reality that has been felt by patients and families in high-income countries. With the overwhelming hospital admissions, and critical care expansion necessary to accommodate the critically ill COVID-19 patients, outpatient visits were curtailed, and elective surgery came to a grinding halt. Many of us have personal experiences of people whose cancers progressed to the point that they were incurable, and palliative care that was all that could be offered. This is the result of a health system which could not cope, and a surgical system under duress. The time to full surgical recovery following COVID-19 is years away, and the potential impact on cancers, and patient prognoses is now devastating globally.[37]

The problem in Africa and other low resource environments is that the experiences during COVID-19 of cancers progressing in high-income countries are an everyday occurrence as there is just not enough surgery. My most visceral experience of the agony for the surgeon, was watching a colleague sitting and visibly distressed next to the emergency surgical board. Our electronic operating theatre booking board, highlights the urgency of the emergency cases in the triage colours from red, to orange, to yellow, to green, based on decreasing urgency. My colleague's patient had been on the board for days and had been bumped down the priority list by red and orange cases throughout the day and night. This is inevitable when there are more patients than operating theatres. She had made a last attempt to get her patient into theatre, but it was not to be. The theatres were full with higher priority cases. The realisation that the last opportunity was lost, was too much, and she broke down in tears next to the board. She knew now that the only option was to give the patient morphine and keep him comfortable. What had started as a simple hernia, a defect in the abdominal wall pushing bowel through the defect was ultimately going to kill him. What was a potentially benign surgical pathology that could be managed with surgery, had now become obstructed, and the extravasated bowel had begun to swell, so that the bowel could not reduce and return into the abdomen, and instead the rising pressure was decreasing the perfusion of the herniated bowel and it was dying. Abdominal sepsis of the bowel has a devastating outcome. This is not an uncommon scenario or presentation in a low resource environment.

The 11 year-old child that sat next to her dead mother lying in a pool of blood[1] is another example of a bigger problem in healthcare in Africa. Limited access to surgery has devastating implications. People die at home for predominantly two reasons. Either they can't get to hospital for surgical care, or they are unaware that many of these 'home deaths' are unacceptable and unwarranted. These deaths at home associated with limited access to care, essentially 'normalise' inadequate access to surgical care and poor outcomes within the community. It is possible that some patients may delay their presentation to the hospital, because of a fear of surgery and anaesthesia. These prevailing belief systems in the community may be compounded by observations that people die after surgery, especially in environments where there is a high case fatality rate. This is likely to exist in Africa, where mortality following caesarean section is 50 times higher than in high-income countries, and mortality following adult surgery is twice the global average.[24 33] These observations could be incorrectly interpreted as 'surgery kills'. But rather, they are the result of patients presenting too late for surgery, and surgery been performed in a low-quality environment due to limited resources.

It is estimated that a functional healthcare system needs to be able to provide 5000 surgical procedures in an operating room per 100 000 population.[31] Based on data from large observational studies,[29 32 33 38 39] one can get a fairly good picture of surgical volume delivered

across Africa, and more broadly in countries across the range of the human development index (HDI) as shown in Table 2.[40] This is thanks to the great work by the National Institute of Health Research (NIHR) Unit of Global Surgery, and Dmitri Nepogodiev who curated and analysed these data. The number of surgical procedures performed across Africa is nearly equivalent to the average seen across all low-income countries globally. The number of operations performed is low, really low. This is at least 10 times lower, than the minimum expected for acceptable surgical provision. Low-middle income countries don't do much better, only achieving a 1/5 of a minimum acceptable volume of surgery for the population, and in upper-middle income countries, a 1/5 of the population do not receive the minimum acceptable volume of surgery.

Table 2. Surgery conducted per 100 000 population according human development index*[40]

Region	Surgical cases	Shortfall	Relative increase to reach target
Africa	482	4518 (90.4%)	10 x
Low-income countries	356	4644 (92.9%)	14 x
Low-middle income	1096	3904 (78.1%)	5 x
Upper-middle income	4028	972 (19.4%)	1.2 x
High-income countries	11 150	0	0

*Target 5000 surgical operations per 100 000 population

The volume of surgery in Africa leaves a lot to be desired.[40] Countries like Chad require 50 times more surgery than currently delivered, and even the relatively affluent African countries such as Mauritius and Namibia still need twice as many surgeries to reach 5000 surgeries per 100 000 population annually.[40] Essentially, access to surgery is wholly inadequate across all income categories, with the exception of the generally over-serviced high-income countries.

What are the implications if you cannot provide enough surgery in Africa and low-resource environments? Appendicitis is a surgical disease from which one should almost never die. It is a core surgical procedure for which every surgeon is trained. Thus, even the worst presentation of appendicitis in high-income countries has an expected mortality of approximately 0.1%, or one in 1000 cases. In contrast, in low and middle-income countries the mortality is at least six times higher, at 0.6%. However, once surgery is unavailable, then the mortality rockets; 10% in moderate cases, and 19% in severe cases at 30 days in low and middle-income countries. The excess mortality impact of this unmet surgical need is devastating. It is highest in Africa between 6500 to 8300 excess deaths per 100 000 patients with appendicitis, followed by South-East Asia at 6300 to 7300 excess deaths per 100 000. The economic burden of not providing surgery to local standards for appendicitis in Africa is estimated to be between 4.5 and 6.3 billion dollars (or 0.13 and 0.19% of total GDP). Globally, the economic burden of not providing surgery for appendicitis balloons to 73 and 92 billion dollars per annum.[41] Importantly, increasing the economic analysis to the ability to provide the best surgical care adds little further economic burden to the analysis; about 0.1 billion dollars per annum in Africa, and 2 to 3 billion dollars globally for addressing the unmet need for appendicitis, a 2 to 3% increase in the economic burden to provide the best surgical care. Almost 97% of the economic burden is through lack of access to surgical care. The message is a clear. The biggest economic burden lies in initiating surgical access. It is imperative that we do all that we can to improve access to surgery. Table 2 shows the extent of the challenge.

How do we get patients to surgery? Social circumstance is a major determinant of access to surgical care. It is tied up with physical and financial access, and patient acceptability (Maria-Lisa Odland and Justine Davies, personal communication). Maria-Lisa Odland and Justine Davies sum up the delays in access to surgical care succinctly as delays in 'seeking', 'reaching', 'receiving' and 'remaining' in care. Health is fundamentally a human condition, and it falls prey to the vagaries on the human psyche and the community in which people live when considering whether to 'seek' care. These include (amongst others): a fear of a lack of privacy, a fear of the community's knowledge of illness, a fear of dying, a patriarchal society where women are not allowed to make decisions about surgery, a distrust in the health system, or the unaffordable cost of accessing the health system. 'Reaching' care is dependent on the physical distance to travel, the conditions of the roads and the travel costs, the potential loss of earnings in leaving work to get medical care, and the dysfunctional, complex and disjointed health systems which result in numerous redundant pathways for the patient.[42] 'Receiving' care is not only dependent on funding, and the training and knowledge of the healthcare providers to make an early diagnosis, but also on the need to communicate and refer across sites and disciplines within the health system, to have and maintain the necessary equipment, staff in the system with the skill to provide the care, and the access to an operating theatre, without an unacceptably long surgical waiting times such that the benefits of surgery are lost.[42] To 'remain' in care, there needs to be the ability to travel, to have the time and money, and then even if these exist, the fear of the community stigma, and the extraordinary waiting times, and possibly a lack of follow up protocols which result in patients been discharged out of the health care system. It makes one despair. Frankly, getting surgery in this environment is nothing short of a miracle.

Any number of factors can contribute to a surgical patient's death. Physical barriers to access could include the distance and quality of roads (which was what led Sue and the medical student needing to do a caesarean section, with limited experience), or financial factors such as cost to access, and loss of earnings within the system. In some countries, if you cannot pay for the 'surgical pack' of disposables and instruments needed for the operation, you will not get to surgery.[43] A complex and disjointed health system can further escalate the physical and financial barriers to access. Poor training and knowledge necessary for an early diagnosis, poor communication within the health system with a slow and convoluted path to definitive care, and limited resources resulting in necessary equipment shortages hampered by poor maintenance further limit access. Insufficient resources mean limited theatre time, long waiting times, long operations with slow turn over due to a lack of supervision of junior doctors, amongst numerous other barriers. The barriers to access are interconnected and demonstrate how accessing care is much more than just a medical issue, but also a social issue.

I was flying home from a meeting, and while in the airport lounge, I picked up a paper to read with my coffee. A small photo caught my eye. It showed an elderly man pushing a wheelbarrow along a sandy footpath through the veld. In the wheelbarrow was an even elder man, probably in his seventies with a wizened face, and grey hair. The caption stated that this was a patient being taken to hospital in the Eastern Cape in South Africa. The irony could not have been starker. Here I am in the same country, about to fly across the country to get home, while someone else has had to be pushed, probably for days, in a wheelbarrow to get to be seen at a under-resourced hospital.

A wheelbarrow is hardly an ambulance, and this is obviously an extreme case. But it highlights how long it could take to get to a hospital. South Africa has a comparatively good healthcare

system, when compared across Africa, however getting to care even in this relatively advantaged environment when compared to the rest of Africa is unbelievably challenging, and disheartening. Here some figures to mull over from the Western Cape which arguably provides the best public sector healthcare in South Africa. At Groote Schuur Hospital, one of the tertiary centres in Cape Town, the estimated average time for a patient to arrive at the colorectal cancer service for cancer is about a year after their initial symptoms (Adam Boutall, personal communication). Breast cancer is the most common cancer among women in South Africa. Yet patient awareness is lacking, and the ability to present to a secondary level hospital breast clinic in the Western Cape takes on average of 67 days (or 10 weeks).[44] The European Society of Breast Specialists accept up to a 6 week delay to a diagnostic breast clinic. The South African guidelines suggests that a woman with a breast lump should be seen within 3 weeks. The problem is that to achieve the 3 week consult and the 6 week diagnostic recommendation, a potential breast cancer patient must navigate multiple delays between the first symptoms and presentation to a healthcare provider. These include the initial denial of a potential cancer, a lack of education of first symptoms of possible cancer, and the difficulty in getting to a healthcare provider. Then there is the provider delay; the delay before referral to a dedicated breast centre, the subsequent diagnostic delay, and finally the treatment delay.[44]

What is the consequence of delayed access to surgery and an inadequate volume of surgery which limits the number of patients receiving surgery? Taking a patient longer to get to a hospital capable of providing surgery has the following three consequences in Africa, all of which contribute to an increase in morbidity and mortality for the patient. Firstly, a late presentation means that the disease will have progressed. The longer it takes to get to surgery, the worse the patient's surgical outcome. The surgery that should have been elective, becomes urgent and emergent surgery. The proportion of surgeries that are emergent is a marker of a lack of access to surgery. The majority of surgery should be elective (or planned) to realise the full benefits of surgery, but in Africa the majority of surgery in Africa is urgent or emergent.[33] Late presentation results in patients presenting with advanced surgical pathologies, and often the opportunity for cure has been obviated by the passing of time. In our collaborative African work, it is not uncommon to see a picture on a regional WhatsApp group of a massive fungating mass covering the breast and thorax of a patient from a clinician in a remote, resource limited environment, asking for help with the diagnosis, and guidance on the management. A patient like this, is often going to die with or without surgery. In Soweto, at the Chris Hani Baragwanath Academic Hospital, the risk of a late stage at breast cancer diagnosis is 1.25-fold higher for every 30 kilometres that the patient is further away from the hospital.[45] A simple 30 kilometres substantially increases the delay in making it to the breast clinic, and increases the risk of death. It is mind-blowing that at 60 kilometres, one in three patients will therefore have a late-stage breast cancer diagnosis. A systematic review of seven cancer types (bladder, breast, colon, rectum, lung, cervix, and head and neck) showed that for each four-week delay to surgery there is a significant increase in mortality, with 10 additional deaths per 1000 women with breast cancer with a four week delay, 20 deaths at eight weeks and 31 deaths at 12 weeks delay in the study.[46] Based on the Western Cape data,[44] we should expect between 20 and 30 additional deaths due to the delay in accessing a breast clinic.

The second consequence of a limited surgical service which provides a low volume of cases, will ultimately only have the capacity to address urgent or emergent surgery, as is evident across Africa.[33] This means that the majority of surgeries which should be elective (or planned) to realise the full benefits of surgery are not seen timeously due to the demand of urgent and emergent surgeries. Unfortunately, in Africa the opportunity for cure associated with planned

elective surgery is compromised by the time lost awaiting elective surgery once in the healthcare system.

The third consequence of limited access to surgical care in Africa, presents a bizarre phenomenon. The proposed benchmark proposed by the Lancet Commission for accessing hospitals for emergency surgical care is two-hours travel time. Similarly, this is the benchmark for accessing emergency surgical care.[31] In Sub-Saharan Africa, only 16 of 48 countries (33%) reached the international benchmark of more than 80% of their populations living within a two hours of the nearest hospital.[47] We tried to determine the impact of distance and time on surgical outcomes in Africa, using the data from the ASOS study (Paul Ouma, Emelda Okiro, and myself, unpublished data). We controlled for patient and surgical risk factors known to be associated with mortality, and then looked at the effect of 'geographical or travel remoteness' on patient outcomes. Interestingly, whether you defined 'remoteness' by distance, or projected time to travel between hospitals, as the distance or time increased, the outcomes improved. The more remote the hospital, that is the further the hospitals were apart, the more likely that the patient was predicted to survive surgery. These data are unpublished, because we found it hard to make head or tail of the signal, but I now feel that I may understand the data. It is counter intuitive that as the distance increased, or as the travel time increased, that the patients presenting at these more remote hospitals were more likely to survive surgery. I think there are several factors at play here. Firstly, when the distances are large, only the fittest patients will make it to the hospital. Indeed, the patient being pushed to a hospital in a wheelbarrow in the Eastern Cape, will clearly be more likely to die as it will take so long to get to care. Undoubtedly, there is a Darwinian survival element to accessing necessary healthcare in low resource environments. Essentially, the harder it is to access care, the more likely that the 'weaker' patients will to be 'selected' to die before they even get to a surgical hospital. This means that the patients arriving at remote hospitals may be the fitter, and better surgical candidates than the weaker patients who have already been 'selected out' and died. Those who make it to the hospital, are essentially strong and 'prehabilitated', and good candidates to survive surgery. In high-income countries, patients are given preoperative 'prehabilitation' programmes to make them fitter and stronger before surgery. This is very common with big cancer surgeries, and the patients end up doing better. For a low resource environment, accessing a hospital far away, may be a long physical struggle, and may be a 'natural' prehabilitation programme. In Africa, hospitals merely need to be far apart to select out the 'strong' patients, and possibly a long trip to a hospital is a form of 'prehabilitation'.

Finally, we do not know much about patient selection for surgery at remote hospitals. From the hospital perspective, either the team develops a skillset to manage surgical problems, or alternatively, the surgical team may be very clear on their competencies, and hence there are certain surgical cases which they will never embark upon, and hence although the surgical outcomes look good (for the surgeries conducted), the broader outcomes for all surgical pathologies (operated and not operated) are worse, as some patients are just never offered surgery. Do remote surgical teams only select the patients that they are confident that they can provide adequate care to, and triage the higher risk patients to no surgical intervention? Sure, it is possible that some remote hospitals provide excellent care, but this certainly cannot be considered the norm. Indeed, it likely that the norm is poorer outcomes in more remote sites. We know that a low volume of surgery is associated with worse surgical outcomes.[48] A study in Liberia where the surgical volume was estimated at 462 cases per 100 000 population (less than 10% of the suggested minimum surgical volume for safe surgery), the determinants of surgical volume were unsurprisingly associated with the availability of human resources, and infrastructure.[48] Until these two key factors of resources and infrastructure are addressed,

surgical provision will remain inadequate, and surgical outcomes will remain poor in low resource environments, despite the best intentions of the surgical team. The odds are stacked against any surgical team and patient in these remote hospitals.

The in-hospital surgical outcomes are awful in Africa. An adult patient is twice as likely to die after surgery,[33] a child is 11 times more likely to die,[49] and a mother is 50 times as likely to die following a caesarean section,[24] when compared to global or high-income countries. Yet, the total number of deaths we have seen in the hospital, are only the tip of the iceberg of 'surgical' deaths. There are numerous uncounted 'surgical' deaths in the community, of patients with 'surgical pathologies' who never get the opportunity to have curative or life improving surgery. From Table 2, we can expect that there are 14 times as many patients in the community with surgical diseases that never get surgery, resulting in many unnecessary (and unseen) deaths from surgical disease. In low middle-income countries there are at least five times as many surgical diseases resulting in unnecessary deaths in the community than what we see in the hospital. There is an unacceptable excess mortality in the community from not providing surgical care. It is estimated that increasing surgical services to provide the Universal Coverage of Essential Surgery could decrease all deaths by nearly a third, and excess disability adjusted life years by a third.[50] Let me say that again. Increasing *only surgical services*, just to provide essential surgical universal health coverage, can decrease *all deaths* by a third, and increase the quality of life for a third of the population!

As we have seen in the Cape Town 'flying squad' data intervention, delays in accessing obstetric care also impact on maternal outcomes. The barriers to access timely surgical obstetric care are numerous,[51] and are similar to the barriers limiting access to surgical care. Maternal access barriers may also be further compounded by factors associated with gender inequality in accessing care.[51] These delays stack up, and besides the risk to the mother, there are also dire consequences for the fetus. In Nigeria, the average time to receiving care is double for stillbirths compared to live births. Here minutes count between good and bad fetal outcomes, with travel times of 15 minutes for live births compared to 26 minutes for stillbirths.[52]

An ectopic pregnancy is a pregnancy in the fallopian tube and not the uterus. This can progress to devasting haemorrhage even if it is diagnosed correctly, but not treated surgically. Recently while on call, a patient with an ectopic pregnancy was wheeled into casualty with an ectopic pregnancy who arrested from hypovolaemia due to massive internal bleeding. Driving frantically to the hospital, a received a second call, and my distressed colleague told me that they despite their ongoing resuscitative attempts, she had arrested a second time, with a prolonged period of resuscitation. I arrived to a patient still on the gurney, cold as ice, with an endotracheal tube in situ, and adrenaline running at an obscenely high rate. She was unresponsive, despite been given all the O- emergency blood available in the casualty. She was still as pale as a sheet, but we would have to wait for more blood and other blood products to arrive from the blood bank across the city. Despite her terrible condition, we had to get her to surgery to stop the bleeding. We were fortunate to have two senior obstetricians with us, and we quickly made the dangerous trip along corridors and in lifts to the operating theatre. In the more controlled environment of the operating room, I was joined by a third anaesthetist, and between us we divided tasks and quickly established more intravenous lines, beat to beat monitoring lines and got her off to sleep. The surgeons were incredible, and literally in minutes they had gone into the abdomen which had been grotesquely distended by blood, and clamped off the uterine arteries. This bought us the time to resuscitate her now that the bleeding had been stemmed. But it appeared futile. Her temperature was 33 degrees Celsius, and her pH was 6.9. If only she could have presented earlier to the hospital, maybe we could have made a

difference. The surgeons carefully closed the abdomen after the operation, ensured that there were no obvious bleeders and we continued to resuscitate her after the surgery. We were relieved when more blood and clotting factors arrived. Now that lifesaving surgery was over, we could access the patient and we removed the cold bloody sheets, dried the patient and covered with her with clean, dry sheets and continued to warm her. Despite the ongoing care, progress was slow. Eventually we left the operating theatre for the intensive care unit, but she remained outrageously cold with a severe metabolic acidosis. Fortunately, against all the odds she recovered, and we extubated the next day and she made it home. This would never have happened without the expert surgical care that she received. However, it need not have been this close. How could she arrive so late in casualty, in the large city of Cape Town?

Unfortunately, there are many patients in South Africa who are not nearly this lucky. In the 2017 to 2019 South African CEMD, there were 119 ectopic pregnancy deaths. These deaths occurred predominantly in district hospitals and in some the initial diagnosis was missed. As expected, four out of five of these women died from hypovolaemic shock from bleeding. In one out of five patients, there was no attempt at resuscitation, but unbelievably two out of five patients did not even get to surgery. Importantly, every one of these deaths should be considered totally preventable. Instead, in 20% of the patients that presented there was no attempt at resuscitation, and another 40% did not even get to theatre. This is what happens when you do not have access to surgery. Young women with conditions which are totally amenable to surgery, die unnecessarily in early pregnancy.[53]

For those patients who made it to surgery and survive, we still have the challenge of ensuring that they remain within the healthcare system, to ensure appropriate surgical follow up. Sadly, just as there are barriers to accessing surgical care, these same barriers are likely to result in patients leaving care after surgery: transport, cost and social stigma.

A final and extremely worrying consideration is that it is possible that the estimate that 5000 surgical procedures are needed per 100 000 population annually, may be an underestimate of the need in limited resource environments. This is certainly possible, because with limited (or an inadequate provision) of surgery, the number of patients requiring surgery will just continue to increase in the community. Some early work in Ethiopia suggests that needs in Ethiopia may be as high as 16 000 procedures per 100 000 patients, that is three times higher than the recommended surgical capacity made by the Lancet Commission for Global Surgery[31] (Desalegn Bekele, personal communication 1 May 2022). The Lancet Commission on the future of health in sub-Saharan Africa has identified that the current pace of health care improvement is unacceptably slow to provide the same health opportunities by 2030 as other countries.[36] Slavishly following the Lancet Commission for Global Surgery's indicator guidelines[31] may further perpetuate this scenario, when one doesn't consider the associated backlog of care needed. Although 5000 surgical operations per 100 000 population should be considered the absolute minimum, it should be individualized to the individual needs of low resource countries, at the demand may be a lot higher than expected.

The missing surgeries

Dolly Munlemvo, an anaesthetist from the Democratic Republic of the Congo (DRC) tells me a story of a young pregnant lady who fell from a tree while collecting wood, sustaining a chest injury. In the DRC, there are few thoracic surgeons and very few general surgeons who would accept taking care of a patient with a thoracic injury in a remote hospital. The patient was in Bandundu, a village over six hours from Kinshasa by car, according to Google Maps. She was

short of breath, and had punctured her lung, requiring a chest tube insertion. As the only thoracic surgery in the DRC was in the capital, she was taken on the back of a motorbike to Kinshasa for thoracic surgical care.

Dolly's story illustrates the importance of being able to provide a range of essential surgeries at district hospitals. The World Bank identified 44 procedures that one should be able to do at the district (or first level) hospital.[54 55] The essential trauma services which require 'expeditious diagnosis and treatment' including the management of a pneumothorax or haemothorax (air or blood outside the lung, but in the chest cavity which squash the lung down) was needed by the lady from Bandundu. This essential procedure is relatively simple, yet it was nearly six hours away.[55] For some, that is too long. Fortunately for this young pregnant patient, it wasn't, and she survived.

The Lancet Commission for Global Surgery identified three Bellwether (or indicator) surgical procedures that should be readily available at a hospital within 2 hours travel time; a caesarean section, a laparotomy (an open abdominal operation), and an open reduction of a fracture.[31] To get an idea how far away we are from realising these targets in Africa consider the following. In ASOS, a 1/3 of *all* surgeries were caesarean sections.[33] In comparison, in the UK, only 2.4% of surgeries are for caesarean sections.[56] Caesarean sections literally drowned out all the other Bellwether procedures in district hospitals. For example, in the district hospitals in KwaZulu-Natal, South Africa in 2015, 96% of the Bellwether procedures were caesarean sections, 2% were laparotomies and 2% were open reductions of fractures.[57] The laparotomies and open reductions are just not being delivered at the district level within the accepted travel time for treatment.

An insufficient volume of surgery (as shown in Table 3) results in a distribution of surgical procedures which is driven by surgical urgency as opposed to population need. As the resources to deliver surgery decreases (reflected by the decreasing human development index), the proportion of emergency surgery increases, the proportion of obstetric surgeries increases, while the proportion of cancer surgeries and 'other' surgeries (surgeries which individually contribute less than 5% of all surgeries performed which include subspecialities such as breast surgery, cardiac surgery, neurosurgery, thoracic surgery and vascular surgery) decrease.

Table 3. Surgical case-mix by Human Development Index Quintile[40]

		Quintile 1	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**
Emergency surgery	Proportion of total surgical volume	25.6%	21.6%	32.3%	58.5%	56.9%
Obstetrics & gynaecology	Proportion of elective surgery	11.8%	13.1%	12.7%	26.4%	36.7%
Obstetrics	Proportion of overall obstetrics & gynaecology	20.0%	40.0%	40.0%	45.0%	47.5%
Colorectal surgery	Proportion performed for cancer*	65.0%	60.0%	35.0%	30.0%	20.0%
Head & neck	Proportion performed for cancer*	17.5%	20.0%	15.0%	10.0%	12.5%
Plastic surgery	Proportion performed for cancer*	40.0%	40.0%	20.0%	20.0%	17.5%
Upper gastrointestinal and hepatobiliary	Proportion performed for cancer*	30.0%	40.0%	30.0%	20.0%	15.0%
Urology	Proportion performed for cancer*	33.8%	30.0%	25.0%	10.0%	10.0%
Other surgery	Proportion of elective surgery	20.7%	21.0%	22.0%	20.5%	10.4%

* The demand for cancer surgery has been corrected by the proportion of deaths attributable to cancer according to the WHO 2016 data,[58] as there is a lower proportion of cancers in low and middle income countries, due to the younger patient profile.[59] In high-income countries, cancer attributable deaths are approximately 27%, while in LIC it is 7.1%, LMIC it is 9.3% and UMIC it is 20.7%.[58]

In summary, if surgery is not readily available, the proportion of emergency surgeries increase, as a large proportion of surgical diseases convert from elective to emergency procedures as the surgical pathology progresses or complicates without timely surgery. The result in an increase in morbidity and mortality. The proportion of obstetric procedures increases[33] at the expense of cancer and 'other' specialised surgeries (which are literally 'removed' in low resource environments). If you have a cancer in Africa, the odds are heavily stacked against you.

How much more surgery do we need?

To understand the surgical volume and surgical case-mix requirements for Africa, and more broadly across all low and middle-income countries, it is instructive to use the United Kingdom as a benchmark for a high-income country, as the UK provides just over 5000 surgical procedures per 100 000 population per annum, or just over the recommended minimum number of surgeries necessary for safe surgery.[40] If we assume that the proportions of surgeries delivered in the UK are representative of need, then we can compare the surgical volumes provided for cancers, benign surgical conditions, obstetrics and the surgical subspecialities which individually contribute less than 5% of all surgeries performed (termed 'other') across human development index groups. This 'other' category is important, as it includes the subspecialities such as breast surgery, cardiac surgery, neurosurgery, thoracic surgery and vascular surgery.[40] The dramatically low volume of surgeries performed across the board are clearly seen in Table 4, and the proportional increase in surgical volume per category is also shown.

Table 4. Surgery conducted per 100 000 population according to surgical category*

HDI	Cancer†	Increase needed	Benign	Increase needed	Obstetrics	Increase needed	Other	Increase needed
Africa	53 (10.9%)	4x	304 (63.2%)	10x	78 (16.2%)	2-3x‡	47 (9.7%)	22x
Low-income countries	22 (11.1%)	10x	122 (61.3%)	24x	37 (18.6%)	2-3x‡	18 (9.0%)	58x
Low middle income	71 (11.7%)	4x	356 (58.5%)	8x	56 (9.2%)	2-3x‡	126 (20.7%)	8x
Upper middle income	519 (14.2%)	1.2x	2150 (58.7%)	1.4x	182 (5.0%)		811 (22.1%)	1.3x
United Kingdom	860 (17.2%)		2975 (59.5%)		120 (2.4%)		1045 (20.9%)	

*Target 5000 surgical operations per 100 000 population
†The demand for cancer surgery has been corrected by the proportion of deaths attributable to cancer according to the WHO 2016 data,[58] as there is a lower proportion of cancers in low and middle income countries, due to the younger patient profile.[59] In high-income countries, cancer attributable deaths are approximately 27%, while in LIC it is 7.1%, LMIC it is 9.3% and UMIC it is 20.7%.[58] (For Africa a conservative estimate of 7.1% for cancer attributable deaths was used)
‡Estimates for African countries[60]

In Africa and other low resource environments, subspeciality surgeries and cancer surgeries should be considered 'neglected surgeries.' That is why our lady in Bandundu, DRC had to

travel nearly 6 hours for a chest drain, and this is why in Soweto, South Africa, your odds for an increased breast cancer staging diagnosis are 1.25 for every 30 kilometres from the hospital.

What we have not considered are children. Although the global surgical case-mix of children is not yet well documented, it is unlikely that this picture of unmet surgical need is any different. Indeed, it is probably worse in the paediatric population due to the higher proportion of young people constituting country demographics in low and middle-income countries. In the Sub-Saharan African countries, children under the age of 15 years account for 42% of the population.[61] A large study of surgery in children in South Africa estimated that we are only meeting between 1/3 to 1/5 of the predicted surgical need in children.[62] This is an important observation, as South Africa is an upper-middle income country, and these countries achieve approximately 80% of the surgical volume needed. The paediatric surgical volume is between 20 and 33% of the need in South Africa, but it is likely to be far worse across Africa which is predominated by the more poorly resourced low- and low-middle-income countries. Paediatric surgery should therefore also be considered a neglected subspeciality surgery. Paediatric surgery and anaesthesia require additional skills, and therefore it understandable that it is proportionally under-represented.

The Lancet Commission for Global Surgery has estimated that approximately 5 billion people lack access to safe and affordable surgery of which there are about 1.7 billion children.[31 63] Surgical disease is estimated to account for 28% to 32% of the disease burden in low and middle-income countries, with the disability adjusted life years (DALYs) lost being double that of malaria, tuberculosis and HIV combined (214 million DALYs).[50] Increasing surgical services to provide the Universal Coverage of Essential Surgery could prevent 32% of deaths and decrease DALYs by 35% in low and middle-income countries.[50]

The multiple factors required to increase access to surgery were well articulated by Desalegn Bekele of the Ethiopian Health Service Quality Directorate when discussing the Ethiopian National Surgery Obstetrics Anaesthesia Plan or NSOAP (1 May 2022). He summarised the solutions into the six broad categories of leadership, a facility with appropriate equipment and workforce, an adequate number of facilities, adequate amenities to support the surgical facility e.g. water, sanitation, roads, electricity, and communication with all stakeholders. Without these factors, access will always be compromised.

Death and dying in low resource environments

When and where do surgical patients die?

Surgery is getting safer. Gaisford Harrison, a giant in anaesthesia and head of the Department of Anaesthesia in Cape Town in the 1970s, tracked anaesthesia related deaths at Groote Schuur Hospital over 30-year period from 1956 to 1987. What he showed was a six-fold fall in anaesthesia related mortality from 43 deaths per 100 000 (between 1956 and 1966) to 7 per 100 000 (between 1977 and 1987).[64] The data showed that before the 1970s, the global anaesthesia related mortality was about 65 per 100 000, and between the 1990s and 2000, it had fallen to about 14 per 100 000.[65]

PJ Devereaux has subsequently taken this outcome work further. PJ is a giant in perioperative clinical trials. He is a Canadian lead cardiologist at McMaster. McMaster is essentially the global epicentre of large clinical trial research, cardiovascular medicine and evidence-based medicine. He has worked with giants in these fields, and he too, is now a giant. He was mentored by David Sackett as a medical student, and then worked with Gordon Guyatt, the two pioneers of evidence-based medicine. As a cardiologist he worked with Salim Yusuf, who is the father of large cardiovascular clinical trials which started with his DPhil in Oxford in the 1980s.[66] PJ has taken his immense understanding of evidence and clinical trials into the surgical space, conducting large research projects and clinical trials in perioperative care globally. It is unsurprising that PJ is a real stickler for evidence, both in its generation through robust clinical trials, and in the delivery of therapies with robust evidence. PJ is forthright in a very North American way. He will be clear in his objectives and will not stand down if he believes you are wrong or misguided, emphasising you mistakes with his index finger. He has really driven the evidence for the care of surgical patients forward with his leadership and large clinical trials. PJ led a global project known as VISION or the Vascular events In noncardiac Surgery patIents cOhort evaluation, which has provided tremendous insight in when, where and why surgical patients are dying. With data from over 40 000 patients globally we know the following about deaths following surgery. Globally, <1% of patients die in the operating theatre. Instead, most patients are dying on the ward before discharge (Table 5).[67] In Africa, the proportion of patients that die on the day of surgery is slightly higher, probably due to resource constraints, but nearly 95% of surgical patients are still dying on the ward postoperatively.[33]

Table 5. Time and location of deaths following surgery

Region	Deaths in operating room	In hospital deaths after surgery	Deaths after hospital discharge
North America, Europe, Australia	1%	70%	29%
Asia	1%	62%	37%
South America	0%	73%	27%
Africa	1%	80%	19%
Worldwide	1%	70%	29%

What are the big complications that are killing these patients. When controlling for patient risk factors, PJ has shown that 45% of mortality can be attributed to three groups of complications; bleeding, sepsis and cardiovascular complications.[67] When PJ talks about the findings of VISION, he speaks passionately about how safe surgery and anaesthesia has become, and he is correct. He is convinced that it is the continuous presence of an anaesthesiologist, aided with beat-to-beat monitoring that has led to the six-fold decrease in mortality that Gaisford Harrison documented. The one-on-one care by the anaesthesiologist in an operating theatre is designed to provide quality care. PJ is correct.

The fundamental problem is that the surgical deaths as a result have moved from the operating room to the postoperative ward. This is because you take a patient who has one-on-one care in the operating theatre, and then quickly de-escalate their care once they arrive in a ward of 30 or 40 patients with limited nursing. Patient observations go from the continuous monitoring in the theatre, to intermittent monitoring on the ward, which can be as infrequent as observations every few hours. What are the implications of this change in the frequency of care?

Most patients die due to a 'failure-to-rescue'

For the surgical patients who dodged the Darwinian bullet by making it to the hospital and received surgery, their struggle to survive surgery is only beginning. They must now still navigate the period where most deaths occur in surgical patients, the surgical ward.[33]

Agya, a Ghanian colleague met one of these patients early in his internship. He had just finished six years of medical training. As a keen young doctor on the ward round, he passed an elderly gentleman with sepsis of the urinary tract. He looked awful. Most of team on the ward round had seen this picture before. He was a 'goner'. They quickly moved on, as there were others to see, and this patient was certainly going to die. Everyone knew, that although he had made it to the hospital, he would die before the next morning's ward round.

But Agya didn't agree. It may have been because Agya had not seen this scenario play out before, or maybe he saw something that made him believe that the patient still had some life in him. As the sun set, and his colleagues made their way home on foot, he turned his attention to the patient. He got one of the few blood pressure machines in the hospital, and wrapped the cuff around the man's clammy arm. He set the blood pressure to cycle every five minutes. He

had the drip running, and as the blood pressure sagged, he upped the drop rate. Agya scrambled for some adrenaline. He had to give the blood vessels an adrenaline squeeze to keep the blood pressure up and the heart a little boost. The blood pressure started to respond. The patient drifted in and out of consciousness.

The patient's temperature sored. He was feverish and needed antibiotics. Antibiotics were difficult to come by, especially to treat a savage infection like this. Agya had heard about an antibiotic clinical trial that had been running in the hospital. It was over now, but he thought that some of the antibiotics may still be lying around. He called his colleague who had been involved in the trial. He had to move, as the patient was clearly extremely ill. Time was of the essence, and the patient didn't have a lot of it. It looked like it was of over. The antibiotic arrived. Quickly, Agya mixed it, and injected it into the drip. The infection was rampant. Despite the adrenaline, Agya had his time cut out to ensure that the patient could hold on long enough for the antibiotics to start kicking in. It was a relentless lonely night, opening and closing the drip clamp, fighting sleep, and responding to the patient's physiological needs.

The sun slowly rose, the ward warmed up, and his colleagues arrived. They could not believe it. The patient who was considered a 'goner' looked good. Agya had done a sterling job through the night. After the ward round, he made his way home, and into bed for a well-earned sleep. There was a certain spring in his step when he returned to work. But the patient was dead. If you turn your back, patients slip away. With a limited workforce, they could not continue with the one-on-one care that Agya had provided, and the patient deteriorated and died as soon as Agya's colleagues turned their backs to attend to the other patients in need.

The rate of surgical complications is generally consistent across the globe following adult surgery,[32 33] and across cancer surgeries.[68] But, surgery is precarious. No matter how shiny your hospital looks, the global complication rate following elective surgery is about one in five![32] Yes, elective surgery, … that is planned and scheduled surgery. It is accepted that most complications are minor, and most patients would accept them as par for the course, but there remains a 5% (or one in 20) incidence of severe complications globally following all elective surgical procedures globally.[32]

In Africa, with limited resources, limited running water, and other challenges, one would expect the complication rate following surgery to be higher. But in fact, it is not much different from the global average.[33] This probably makes little sense. But there are reasons which may explain this scenario. Probably the main reason is that this comparison is purely numerical. It is not risk-adjusted for other patient and surgical factors associated with complications. In reality, the classic inverted funnel shape of the African population demographic reminds us that surgery in Africa is conducted predominantly on younger and healthier patients than that seen in a global average.[33] So if risk-adjusted, complications would in reality be worse in Africa than reported elsewhere.[69] But let's forget that for the time being, and accept that proportionally the complication rate in Africa are similar to the global average.

Most complications get better. However, a complication which progresses and results in death is known as 'failure-to-rescue'.[33] 'Failure-to-rescue' could be considered a performance benchmark. It tells us a lot about the medical system at large, and its ability to respond to the patient in need. In Africa, 'failure-to-rescue' following surgery is twice the global average.[33] Agya's patient is a typical example of 'failure-to-rescue'.

Let's put that into context. Elective surgical patients in Africa are younger and fitter than the global average. But despite being young and fit, when patients in Africa complicate (and patients complicate often), they are twice as likely to die.[33]

Most people would not accept this postoperative surgical risk. But unfortunately, it doesn't end there. Mothers are a totally different story. Complications following caesarean section in Africa are about 2½ times that of high-income countries, but the mortality is 50 times that of high-income countries. Failure to rescue following caesarean section in Africa is 20 times that of high-income countries![24] I will repeat that: mothers in Africa are 2½ times more likely to complicate following surgery, but 20 times more likely to die if they complicate!

How can all adult surgeries have a failure to rescue of twice the global average, but caesarean sections in Africa run at 20 times the global average? Ten times higher than the average surgical 'failure-to-rescue' rate? What is it that sets caesarean sections apart from other surgeries?[16]

The answer lies in the type of complications which kill mothers, compared to other adult surgical patients. It is the rapidity of the complications that kill mothers. Following caesarean section, one in five mothers who complicate, complicate with a significant bleed that puts them at risk of death. Of the mothers that die, one in four will die following a bleed.[24] We know from the earlier discussion, that the high uterine perfusion rate means that a mother could bleed out in under ten minutes if the bleeding is not stopped. The other major contributor to maternal deaths is anaesthesia complications.[24] Like bleeding, these complications move rapidly if not adequately dealt with. When the airway is compromised, death is only minutes away.

And how does massive haemorrhage present? Death is not loud and violent as it is often portrayed in movies. Indeed, mostly it is quite and solitary. Mothers may slip away, with unrecognised bleeding at home or in understaffed wards at night. As the blood drains out, the perfusion of the brain falls, the mother gets drowsy and then drifts into unconsciousness, and then she is gone. Often without a murmur. Alone, in a bed in a cold surgical ward. No one notices, as the blankets are thick and pulled up to keep her warm, but the under sheet, and the mattress is soaked in a pool of blood which has been pouring out and keeping her warm, while she was so desperately cold. It is easy to miss this untimely death. This is 'failure-to-rescue' at the coal face.

Why are these mothers missed? This raises so many questions. Is it because these mothers are generally young and fit, and no one really expects them to die? Is it because there are other louder, and sicker patients that are dragging our attention away from the routine observations that are necessary to make sure everything is fine? Is it that the resources are insufficient to keep track of all the patients, especially those who are so vibrant and young? Or is a symptom of a larger societal problem, where women do not have a voice?[70]

There are several large studies which document surgical outcomes globally. These allow interpretation of surgical outcomes in lower resourced environments, such as Africa (Table 6). Mortality is twice as likely in Africa following adult surgery,[33] 50 times higher following caesarean section,[24] and 11 times as likely following paediatric surgery[49] when compared to high income countries.

Table 6. Mortality and global surgical outcomes

Cohort	Region	Date	Mortality	Outcome
Adults				
VISION[71] (all surgeries)	Global	2007-11	30-day	1.9%, 95% CI 1.7%-2.1%
ISOS (elective surgery)[32]	Global	2014	In hospital	0.46%, 95% CI 0.4-0.52
ASOS (elective surgery)[33]	Africa	2016	In hospital	1.1%, 95% CI 0.8%-1.4%
ASOS (all surgeries)[33]	Africa	2016	In hospital	2·1%, 95% CI 1.9-2.4%
Paediatrics				
APRICOT[72]	Europe	2014-15	30-day in-hospital	0·1%, 95% CI 0·07%-0·14%
ASOS-Paeds[49]	Africa	2022	In-hospital	2.3%, 95% CI 2.0%-2.6%
Caesarean section				
NSQIP[73]	United States of America	2006-12	In-hospital	0.01%, 95% CI 0.01-0.02%
ASOS[24]	Africa	2016	In-hospital	0.5%, 95% CI 0.3%-0.8%

CI confidence interval

The frequency and type of complications also differs in Africa. In a larger international cohort, the Vascular events In noncardiac Surgery patIents cOhort evaluatioN (VISION) study showed that the most common complications were major bleeding (15.6%), myocardial injury (13.0%), and infection (8.9%).[67] These complications explained nearly half of all deaths. In Africa it is slightly different. The complications which dominate mortality following adult surgery in Africa are mostly infections, and haemorrhage in mothers.[24 74]

If we want to improve surgical outcomes on the wards in Africa, we need to understand what complications are killing, and when and where these complications occur. Then we will be able to develop strategies to improve surgical outcomes. We know that patients die predominantly on the postoperative ward and on average, at least 5 days after surgery, which suggests that there is time to save these patients,[33] and prevent 'failure-to-rescue'.[32]

How poor-quality care further compromises outcomes

'Jenny, Jenny!' I screamed as I ran out of my theatre and down the 'operating theatre street'.
'Jenny, where are you?' I was frantic. I ran into one theatre, and she wasn't there. Out and into the next theatre. The same, not there. Out and into the next theatre. There she was.
'Bruce what's wrong?'
'Jenny, I have put a spinal anaesthetic in, and the patient has no blood pressure. What do I do?'
She responded calmly, 'Give some ephedrine, the patient will be fine.'
I bolted without thanking her. Into my theatre, fumbled in the anaesthetic cart, found the ephedrine and drew it up.
'How much do I give?'
I placed the syringe in the injection port, but something felt wrong. The dose? Seems massive to give 50mg. I looked at the pale patient.
'I think I can get to Jenny and back before the patient dies.'
'Jenny!'
I sprinted out again.
'5mg Bruce, then repeat if necessary.'
'Flip!'
I sprinted back. Gave a little bit.
'You okay! Hello!' A shake of the patient. A bit more. Open the drip full. 'Hello!' Not too responsive. Breathing though. A bit more. The blood pressure machine cycles again. Thank

goodness. At last, little bit of blood pressure. Systolic pressures in the 50s. 'Hello!' A shake of the patient. A bit more ephedrine.
The patient looks at me quizzically. Thank goodness. A response. The blood pressure machine starts cycling again.
'Doctor, I feel sick.' Systolic pressure 90.

I really thought the patient was going to die on the end of my spinal needle that day. Without Jenny, the patient probably would have, or it would have been close. I was lucky to have had a mentor working with me, which allowed me to provide '*safe'ish* care', albeit a bit late. Jenny had been helping someone else, but she got me on track, and got me to give a safe dose too. Fortunately, I decided on one more sprint across theatres to Jenny, otherwise I would have given a dangerously large dose. It is incredible how quickly things can, and a patient could die right in front of you.

I was working in Edendale Hospital at the time, a large regional hospital in KwaZulu-Natal, South Africa. It had a fantastic anaesthesia diploma training programme led by Dr Jenny King. She was diminutive Scots woman, fiery and strong (as you would expect), but as the same time a mother figure to us all. Because of her strong leadership, and fantastic programme for aspiring young anaesthesiologists, we flocked to Edendale from across the country. I was one of the lucky few who made it into her department. Jenny would later be recognised by the World Federation of the Societies of Anaesthesiologists (WFSA) for her contribution to anaesthesia education. She had the highest conversion rate to subsequent specialist anaesthesiologists out of all the of non-specialist anaesthesia training programmes in South Africa at the time. She was that good. She created a love of the profession, through her passion for anaesthesia.

But how could the wheels come off so quickly? This is the stark reality for many who provide anaesthesia care for caesarean sections in low resource environments. Fortunately, my patient was fine, but many women in a similar scenario in Africa unfortunately die. Why? The first clear issue was my complete lack of knowledge of how to handle the situation. I was lucky to have an experienced supervisor, but for many providing anaesthesia in low resource environments this is non-existent, which may result in a poor situation converting to a catastrophic outcome like death. We did not have one on one supervision at Edendale, but we did have Jenny who undoubtedly must have saved many complications progressing to death. However, for many anaesthesia providers working in district hospitals in low resource environments, this is not the case. This same scenario could easily have played out for Sue Fawcus' medical student who gave the spinal anaesthetic for the caesarean section in Zimbabwe.

While surgical outcomes are worse in Africa for adults, children and mothers requiring caesarean sections, the quoted proportional increase in mortality compared to the global mortality of twice, 11-fold, and 50-fold will vary between sites based on the quality of care at each site. One will only know the real quality of care if you track these important outcomes at each site.

Spinal anaesthesia is an easy way to start anaesthetics. With a beautiful fine needle, and a patient with a thin back allowing one to feel the spaces between the vertebral spines, it is possible to gently insert the needle through the interspinous ligament and into the dural sac. With a small pop, the cerebrospinal fluid starts to gently flow back out the needle. With as little as 2 millilitres of local anaesthetic, a patient quickly develops paraesthesiae and then loss of muscle function, allowing surgery on the lower legs, and into the abdomen. This is how most

caesarean sections are done. This is how I got into trouble at the start of my anaesthetic career. I was gung ho. Characteristic of most resource-limited medical environments, I was at the educational stage of 'do one', in the 'see one, do one, teach one' training philosophy. I had just 'done' my spinal anaesthetic, when the patient's blood pressure plummeted, and she became drowsy and less responsive. I felt that she was going to die in front of me, and it may well have happened without Jenny.

The risk of mortality is associated with the resources and the quality of care it allows one to deliver. But quality of care is not only dependent on the resources. From the Donabedian perspective,[75] quality of care is also dependent on the relationship between structures (e.g. adequate staffing), processes (e.g. adequate ward routines for monitoring patients) that determine outcome. Now imagine if I had this experience of the patient with the low blood pressure following the spinal anaesthetic in a hospital with even less resources than mine. Either no supervision, or unavailability of a simple drug necessary to respond to the fall in blood pressure. What would be a relatively common and easily managed side effect, would quickly convert into a life-threatening complication. Similarly, I could have done better at Edendale if the processes for managing a falling blood pressure were available, either through better education or memory aides in the operating theatre. This would have saved valuable time in responding to the complication.

Social inequality is intricately tied to these challenges in delivery of quality of care prevalent in low-resource environments. Social inequality results in an inability to pay for health care, access to subsidised health, or have the means for co-investment in health. From a non-financial perspective, providers and resources are more likely to be present in advantaged communities. Poor social circumstance is certainly associated with low quantity and quality of surgical provision, and the associated poor outcomes.[76]

Zane Farina is an anaesthesiologist in KwaZulu-Natal, South Africa, a friend and colleague who has worked extensively in maternal outcomes and community obstetrics and anaesthesia. Caesarean sections are the most common procedure in Africa, contributing to a 1/3 of all surgical procedures.[24] As a confidential enquiry reviewer for maternal deaths in South Africa, Zane describes a common scenario he has seen when reviewing maternal deaths.[77] Caesarean sections need to be promptly available to manage fetal distress, but unfortunately it may be the provision of a spinal anaesthetic for the caesarean section by an inexperienced provider which results in a mother dying. Zane reports that many death reports received from the attending clinicians go like this. "*The fetal heart rate was falling. We got the spinal anaesthetic into the mother quickly, and the spinal was going well and then the patient suddenly died. We don't know why she died so it must have been a pulmonary embolism or amniotic fluid embolus.*" These are seen as sudden and mostly unavoidable deaths, that the patient could not have been saved from. However, it is possible that in many cases the cause of death is different to what the clinicians have ascribed it to. Without Jenny, I may well have provided a similar report to the confidential enquiry.

Four out of five mothers who die in South Africa, die following a spinal anaesthetic.[77] The real problem though, is that a spinal anaesthetic is decidedly simple. In a resource limited environment, this results in the anaesthesia for the caesarean section being delegated to less and less competent individuals, often healthcare workers who wouldn't dream of doing a simple general anaesthetic. The result is that the skills to identify the physiological warning signs are missed in the patients who die, which a skilled anaesthetist well-versed in human physiology would spot a mile off. For the unfortunate junior anaesthesia provider, the first sign

may be when the heart stops. The first warning to the surgeon, may be the darker, deoxygenated blood, or the decrease in bleeding at the surgical site. These are the things that could have happened to me, if Jenny was not around to help me, or we didn't have the drugs to manage the complication. The problem with the confidential enquiry reports are that the reporters only speak about the classic sudden death events, such as pulmonary or amniotic embolus, but the much more common poor managed hypotension with a high spinal anaesthetic, are frequently unappreciated by junior anaesthesia providers, and may well be the real cause of death in many cases, and not the pulmonary embolism or amniotic fluid embolus to which the death had been ascribed.

I suspect that this scenario is common in Africa. We found that nearly a ¼ of all caesarean deliveries are administered by non-physician anaesthesia providers.[24] So human and other resources are certainly a contributing factor. However, as Donabedian predicted, even if you control for the resources available at a hospital, then the processes will determine differences in patient outcomes. If I had memory aide and ephedrine drawn up in the operating theatre, I would have provided better care in the identically resourced environment. A study which assessed the outcomes of patients in hospitals with similar levels of birth attendants (i.e. resource characteristics) demonstrated that maternal mortality varied between six and 12-fold across these middle income countries, and neonatal mortality between three and fourfold.[78] I had no structure to support the processes necessary for safe anaesthesia when I gave my spinal anaesthetic, and that nearly led to a catastrophe. I am not alone. Clinicians across Africa have asked for similar support for ensuring the delivery of safe, quality surgical care. The challenge of delivering the processes necessary to provide quality care are evident in a study of research priorities for Africa. Training and monitoring of patients in Africa were considered the two most important priorities.[79] Clearly, there is a discomfort with the level of training to provide safe perioperative care (the processes), and the level and availability of monitors (the resources) to track the progress of surgical patients.

Surgical health matters

In a world with perceived limited resources, should we really focus on surgery? The simple answer is '*Yes, we should*.' It matters that there is too little surgery, that surgical outcomes are poor, and the quality varies across hospitals and countries with similar resources in low resource environments and Africa. Until people are healthy, their ability to provide for themselves and their families are compromised, and so too, is their ability to contribute to society.

Surgery matters for five clear principles. The first principle is that surgery is conducted on (mostly) well-defined risk-benefit considerations, to ensure either improved survival or quality of life. However despite these clear benefits, if surgery was considered as a disease category on its own, it would be associated with the third highest mortality globally, only trailing coronary heart disease and stroke, accounting for nearly 8% of all global deaths.[80] That is 4.2 million deaths annually occur following surgery, of which half occur in low and middle-income countries. The number of deaths following surgery exceed the deaths from HIV, tuberculosis and malaria combined.[80] Despite the clear benefit of surgery based on the accepted indications, we cannot continue to accept the excess mortality seen in low resource environments due to limited access and poor quality surgery. Addressing these factors would have a massive impact on the global deaths.

The second principle is that the distribution of the global population is moving towards low and middle-income countries. By 2100, 40% of the world's population will live in Africa, and 80% in low and middle-income countries. It is projected that the world population will be just over 10 billion, with approximately 4 billion people living in Africa and a further 4 billion in Asia. Therefore, 80% of the global population will be living in relatively low-resource environments. The proportion of excess morbidity associated with necessary surgical procedures will therefore increase in the foreseeable future, due to the higher mortality associated with surgery in low-resource environments. This will have a profound effect on the health of the global population with the increase in morbidity and mortality following surgery in low-resource environments.

The third principle is that the access to surgery needs to be dramatically increased in these low-resource environments if we are to be able to provide the necessary surgery for all. Increasing surgery as much as 14-fold in low-income countries and fivefold in low and middle-income countries will catapult surgery associated deaths above stroke and coronary artery disease, into the leading cause of death globally. Sadly, the increase in surgical volumes will be in countries with limited resources, where there is already excess mortality associated with surgery, and limited resources and processes limiting an acceptable quality of care. We to intervene now.

The fourth principle is that the ability to provide surgery requires skills of surgeons and anaesthetists which are cross-cutting between disciplines. These cross-cutting skills make a health system more resilient, by providing a backbone of emergency and critical skills across medical disciplines which will prevent deaths in other fields. The lady in Bandundu who fell out of a tree, could easily have been managed near where she injured herself, had there been the most basic thoracic skills and resources available to insert a chest drain. Indeed, she was lucky that she did not die from this injury over a six-hour trip, but others may not have been so fortunate. The inability to provide adequate anaesthesia support, results in an erosion of emergency and airway skills which are developed and maintained by the ability to provide general anaesthesia. These skills also have the potential to save a mother, and bring life-saving skills to other parts of the hospitals and the health system. For example, besides making surgery safer, the ability to provide safe anaesthesia ensures that there are providers who have the skills to manage airways (whose importance was so acutely experienced during the COVID pandemic), manage massive bleeding, which is of value in trauma, skills in intravenous access which is important in difficult cases like paediatrics who are particularly vulnerable to fluid losses with diarrhoea and at risk of death from dehydration, and the organ support necessary for the critical care patients. Zane refers to these transferable skills as '*cross-training*' which increases the resilience of the medical system, and improves the quality of care.

Finally, the fifth principle is that the provision of surgery can go a long way to address the sustainable development goals (SDGs).[81] Through the ability to improve health and the quality of life, surgery contributes towards ending poverty by promoting health and a healthy workforce, surgery promotes good health and well-being, surgery promotes decent work and economic growth, surgery supports industry, innovation and infrastructure, surgery can reduce inequalities, and surgery can promote peace, and justice and strengthen partnerships for goals.[81]

Based on these five principles, persistence of the current surgical inequity could possibly result in one of the biggest global health crises if we do not urgently address it now. Health equity will never be achieved until we increase the surgical volume, ensure that the 'neglected surgeries' are available to all patients, ensure the postoperative ward becomes a safer space, and ensure that the quality of care is amply supported by resources and processes. The

challenge to deliver safe surgery is enormous. If safe surgery is defined by the whole package of timeliness, surgical capacity, safety and affordability, then approximately 5 billion people globally do not have 'access' to safe and affordable surgery. However, the proportion of populations without safe surgery varies across regions, maxing out at a distressing 95% of the population in south Asia and sub-Saharan Africa, compared to an impressive 5% or less in Australasia, North America, and western Europe.[82]

To put the impact of a lack of safe surgery in context in Africa, we could compare it to the totally unacceptable current maternal mortality rate for caesarean sections of 543 per 100 000 operations.[24] Using the same metric, the adult surgery in-hospital mortality rate in Africa is 2100 deaths per 100 000 population.[33] The excess mortality following surgery in Africa is about half that (or 1050 deaths per 100 000 population) which is double the maternal mortality rate. And the current maternal mortality rate is similar to that of the United Kingdom in 1900! We have such a long way to go to make caesarean deliveries and surgery safe in Africa.

African Surgical OutcomeS-2 (ASOS-2) trial

To improve the outcomes of surgical diseases and realise the benefits of surgery, we need to do the following. Firstly, we need to increase the access to surgery, that is getting more patients into hospitals.[41] Secondly, we need to increase the scope and volume of surgery offered in these low-resource environments. Thirdly, we need to decrease mortality through decreasing 'failure-to-rescue'. Finally, we must ensure quality surgical care. Of these four drivers, the one which we can address immediately is 'failure-to-rescue'. Potentially, it does not have a requirement for any extra resources, as it can theoretically be addressed by process changes within the health system. We thought that if we could address 'failure-to-rescue, we would then improve the quality of care and decrease mortality across Africa.

When we analysed the results of ASOS we were horrified. How could twice as many people die in Africa compared to the rest of the world, just because they needed surgery? And, then when we saw that a 1/3 of all surgeries in Africa were for caesarean section, we were mortified that their mortality was 50 times that of high-income countries. It felt like women were literally dying across Africa, just because they were carrying children. And these deaths appeared to be due to a failure to adequately identify and treat the deteriorating patient following surgery. Our hypothesis was that the lack of human resources (at 20 to 50 times less than what was recommended to deliver safe surgical care) meant that there were not enough healthcare providers to identify all the patients who were deteriorating postoperatively, and intervene timeously to save them.[33] There was a genuine desire to rise to the challenge across Africa, to rapidly reverse these excess deaths following surgery.

It is difficult to explain the urgency for positive change that the African Perioperative Research Group (APORG) felt following the findings of ASOS. I had been a nerd most of my life and had been involved in traditional global clinical trials which usually take upwards of six years from conception to publication of the results. We felt that this was just too long. It was unacceptable to think that we could allow surgical patients to continue to die at this rate following surgery across Africa, and that 1 in 200 mothers could continue to die following caesarean section, 50 times higher than high-income countries. The group were desperate to do something. We felt that if we could increase postoperative surveillance of the high-risk surgical patients, we could identify the patients who were developing complications earlier, and then we could escalate their therapy early, and decrease the number of complications leading to mortality. We honestly believed that we could decrease mortality across Africa. If we could do this quickly, within a year or so, then we could show a generalised intervention which could be deployed across Africa, and hopefully mortality following surgery would plummet.

So, we quickly set about establishing a large trial across Africa to demonstrate that increased postoperative surveillance for high-risk patients would improve the quality of care through early identification and management of patients who developed complications following surgery. This resulted in the African Surgical OutcomeS-2 (ASOS-2) trial. It was designed as a large cluster randomised trial across Africa, which would randomise about 300 hospitals to providing normal care, and another 300 hospitals to providing increased postoperative surveillance to the patients at highest risk of postoperative complications and death. These high-risk patients would be identified by a risk stratification tool we had developed during ASOS (the ASOS Surgical Risk Calculator).[83] The idea was to focus the limited available care on these high-risk surgical patients by providing increased postoperative surveillance in attempt to decrease 'failure-to-rescue'. The interventions were simple and included admission to a higher care ward than planned if it was possible, increased nursing observations, ensuring

the patient could be seen from the nursing station, allowing family members to stay with the patient in the ward and placing a 'high-risk patient guide' at the bedside. The teams were advised to offer as many of these interventions to the high-risk patient for as long as possible postoperatively.

We recruited 332 hospitals from 28 African countries between May 2019 and July 2020 with 160 hospitals (13 275 patients) randomised to increased postoperative surveillance and 172 hospitals (15 617 patients) to standard care. The trial was stopped early, due the immense pressure of the COVID pandemic on the hospitals and clinicians across Africa. What we found was distressing. Despite been able to identify the high-risk patients using the ASOS Surgical Risk Calculator tool,[83] we did not decrease in hospital mortality or severe complications with increased postoperative surveillance.[84] We essentially made no difference at all to the patient outcomes. Why? How could this happen? It made no sense at all.

We had literally spent thousands of hours running ASOS-2. I was convinced that we could get the trial done in a year, and that we would provide a definitive answer on how to improve outcomes for surgical patients across Africa. I am an optimist and I pushed hard. We developed and wrote the ASOS-2 protocol fast. I was continuously badgering my colleagues in tutorials we ran in the early mornings before surgery, looking for evidence on managing 'failure-to-rescue' to include in the protocol. We were consuming papers on early warning scores, quality improvement, teamwork and the like. As we pushed through to ethics approval, the university bulked at the concept of a trial of 60 000 patients across Africa where the one group was 'clearly' going to get more care, than the standard care control arm (which sadly in the end was not the case). The insurance for a trial like this is prohibitively expensive. Insurance for mortality or morbidity which is considered trial related costs millions, and the university was terrified to be the sponsor. We met with the head of finance, and the ethics chair supported me, as I made the case that this is a 'low-risk' intervention. We were going to do clinical care better. If we didn't win with finance, the trial would have been shelved before it got out of Cape Town. Fortunately, and to the credit of the university, they eventually agreed that this trial could run without insurance. It was a calculated risk, for which I am immensely grateful, and a necessary step towards improving quality care through simple pragmatic trials. Then I spent the next two years cajoling, calling, and messaging colleagues with WhatsApp, Viber, and Telegram to build the network to get to the massive number of patients we needed to answer the question. I had country WhatsApp groups, hospital WhatsApp groups, leader groups, strategy groups, you name it, we had it. I ungraded my phone during the trial, and the sales lady who was transferring all my data, asked if I wanted WhatsApp backed up. 'Of course,' I said. To which she responded, 'All 10 thousand plus of your messages.' A colleague used to jibe me about my bleeding thumbs from incessant messaging. We had to navigate ethics boards across the continent, meet them virtually to explain why we were doing this, why it was important, and why we could not afford $500 dollars for every ethics board review. We had sites deep in the DRC with little internet where the trial case report forms would move across the country in trucks to Kinshasa for uploading. We used Google Translate day in and day out to answer questions in French and Portuguese and Arabic. And then COVID hit. New challenges. Clinicians were terrified about this new virus which was ravaging populations. Some friends across the continent had little or no personal protective equipment (PPE) to provide care. The trial was now a risk. In some circumstances it could result in an unnecessary exposure of clinicians to patients and patients to clinicians increasing the risk of infection. The trial literally came to an end.

It felt like a relief. It had consumed two full years of my life, and that of many others. Night and day. We were about to change the world. But, little could prepare me for the first blind analysis results, shared by the biostatistician. No difference in outcome! No difference. It can't be correct. While I was reeling through Elizabeth Kubler Ross' six stages of acceptance, I kept thinking, that one of the sensitivity analyses was going to show that increasing postoperative surveillance improves patient outcomes. Surely 'high-risk' surgeries, and the 'very high-risk' patients will benefit. And when these results came through. They were the same. No matter how you looked at it, there was no benefit associated with increased postoperative surveillance. I had failed all these colleagues across the continent. How were we going to explain this? How would people accept our work? What did it mean for the challenge of improving surgical outcomes in Africa, and more broadly in low resource environments?

I have failed often, but not quite as spectacularly as this. But I had learnt that failure is the greater teacher than success. And this experience probably was the biggest learning point for me. It is this learning which has led to the rest of this book. It was the result of two events. The first was sitting with Rupert Pearse in his kitchen in London, when ASOS-2 was about to start. He said; '*Bruce, you really need a process evaluation.*'
I responded, '*What is a process evaluation!?*' I was so naïve.
'*At the end of the trial, you need to understand what really happened on the ground when you were trying to implement these simple interventions for postoperative surveillance*,' he said.[85]

I took Rupert's advice, and I discussed and learnt from Rupert and Tim Stephens who had already had a tough learning experience in a large quality improvement project across the National Health Service (NHS) in the United Kingdom which failed to show benefit.[86] Rupert clearly realised how difficult our task was. He built a safety net for us with the process evaluation and opened a door to understanding care in Africa in ASOS-2. What we found was that the implementation of the trial intervention package in these resource-limited environments was difficult, and in reality, it outstripped the limited resources at the sites. We learnt that for an intervention to be successfully implemented in the environment, it would require leadership (surgical staff enthusiasm, and nursing management support), teamwork across the surgical team and ensuring that the intervention was 'context-appropriate' for the setting or environment where it was to be used. We will never know if the failure to improve outcomes in ASOS-2 was because we failed to implement the intervention of increasing postoperative surveillance, or if we did not have the resources to respond adequately to the patient's deterioration, or if the interventions to improve outcomes were not initiated.[85] It is likely that is was a bit of all of these. What was clear however, was that the 'soft skills' of leadership and teamwork were key to improving the quality of care, and that any quality improvement interventions need to be tailored to the specific setting in which they are to be implemented.

The second big lesson came from the clinician investigators across the continent. Before the results of ASOS-2 were known, we asked them about their thoughts and experience of the trial and implementing the intervention. The overwhelming response by the clinicians across Africa was that they believed that the intervention of 'increased postoperative surveillance' would decrease 'failure-to-rescue' and decrease mortality.[85]

So, I wasn't the only optimist. I wasn't the only one who believed we could improve care in Africa. I wasn't the only one who believed attention to the high-risk surgical patient postoperatively on the ward would make a huge difference. This has led to a lot of soul searching, reading and discussion for us, to try work out what the issues were that led to us

being unable to show any benefit for the patients. The clinicians across Africa were astounded that we failed to show increased survival, but even after the negative finding the group still believed that increasing postoperative surveillance would decrease death postoperatively.

So, what would we have to do, to ensure we decrease ‘failure-to-rescue’ and improve the quality of surgical care in Africa, to advance health equity?

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