NU-05 Splints, braces, prostheses and aids from local materials

HEALING after the FALL, research library, NU-05

Researched 10 October 2026 by Claude Opus agent for THRIVING after the FALL, Book Four. Library document, unverified.

What this report covers and what it leaves to others. This report is about making and fitting devices: the artificial leg, the brace, the crutch, the wheelchair, the protective shoe, the cane and the ear trumpet. How many amputees walk again, and how the stump is trained, is in NU-04 (its section 1.8 and Protocol 3), and this report cites it rather than repeating it. Splinting a fracture, making plaster of Paris from gypsum and the Thomas splint are in WO-05. The stump in its first year is in WO-09. Spectacles are in CH-08. Spinal injury, paralysis and the pressure cushion in full belong to NU-09, which had not been written when this report was finished, so this report touches cushions only where a wheelchair cannot be discussed without them and leaves the rest to NU-09.

Throughout, three things are kept apart: what a tradition or maker claims, what has been recorded, and what I infer. Inferences carry [VERIFY].

1. Findings by section

1.1 Who needs a device, and how many

The WHO standards for prosthetics and orthotics estimate that about 0.5% of a population needs a prosthesis or orthosis, that two to four times as many people need an orthosis (a brace) as need a prosthesis, that one trained clinician can serve 300 to 600 users a year, and that a service unit serves 1,500 to 2,000 users a year (WHO 2017). The WHO wheelchair guidelines put the need for a wheelchair at about 1% of the population, some 65 million people, and estimated that 20 million who needed one in 2003 did not have one (WHO 2008).

On those rates a village of 300 holds one or two people who need a limb or brace and three who need a wheelchair, and a district of 3,000 about 15 and 30. [VERIFY] These are my inferences from population rates. After a war or a collapse with many injuries, untreated fractures, leprosy and diabetes, the share will be higher. The rates also say that a district needs one person who can make and repair devices, not a factory.

1.2 Artificial legs: the tradition, the record and the inference

The peg and its history. The tradition is old. Ancient finds include a wooden and leather toe from Egypt, which tests by Finch suggested could be walked on, and the Capua leg of about 300 BC, a bronze-sheathed wooden leg destroyed in the Second World War (Strange Remains 2014, secondary). Herodotus tells of Hegistratus cutting off his own foot to escape and walking on a wooden one (Strange Remains 2014). Peg legs were common among civilians for centuries. I found no outcome data for any of this, only objects and stories. The claim that a peg serves is old and plausible, and the record is silent.

Werner, writing for village workers, warns that the bent-knee peg, on which the person kneels, causes a fixed bent knee over time and should be used only as a temporary limb. A straight-knee limb must spread weight over the whole stump, with the main load just below the kneecap, no pressure on bony points or the shin, and a little space at the

tip (Werner 1987, ch 67). WO-09 states that a well-made traditional peg or pylon lasts longer than any modern limb and is better in wet ground (THRIVING library, WO-09). I found no source for that statement and would mark it [VERIFY]. It is plausible because a peg has no foot to wear out, and in Verhoeff's study the foot was the part that failed first (see below).

The American Civil War: a limb industry and why many refused it. About 60,000 amputations were done on both sides, and about 75% of amputees survived, from 96% after part-foot amputation to 17% after amputation at the hip (Prechtel-Kluskens 2014). WO-09 gives 29,980 Union amputations with 24.3% mortality (THRIVING library, WO-09), which fits the same picture. In July 1862 Congress appropriated $15,000 for limbs at $50 a leg, against an estimated Northern need of 6,400 legs and 5,500 arms (Civil War Monitor, undated). By 1870 about half a million dollars had bought about 7,000 limbs, and about 150 patents were filed (Keene State, undated). A new limb was allowed every 5 years from 1870 and every 3 years from 1891, with cash instead of a limb at $75 for a leg (Prechtel-Kluskens 2014).

Two lessons matter for a village. First, a limb wears out and must be replaced on a cycle, which the government recognised in law. Second, "veterans often chose commutation instead of a limb" (Prechtel-Kluskens 2014). The reasons recorded were a poor stump, discomfort, chronic infection, and pride in the empty sleeve. Many arm amputees found a hook more useful than a hand (Keene State, undated). James Hanger, wounded at Philippi in June 1861 and probably the first amputee of the war, carved a hinged leg from oak barrel staves and later supplied the Confederacy at $200 for an above-knee leg (Library of Virginia, undated, search summary). Ayres, wounded in 1864, still had a stump that was "numb and painful" with an adherent scar in 1886 (Prechtel-Kluskens 2014). A limb is only as good as the stump it fits.

The ICRC polypropylene limb. The ICRC began its physical rehabilitation work in 1979 with wood, leather and metal, moved to polypropylene sockets in 1988, and made its first polypropylene knee in Cambodia in 1991 (ICRC 2006, ICRC 2011). From 1979 to 2010 it ran 144 projects in 44 countries and one territory, growing from two centres (ICRC 2011). In 2010 alone it supported 84 projects in 25 countries and produced 20,283 prostheses, 45,129 orthoses, 2,474 wheelchairs and 14,908 pairs of crutches. Children were 28% of those served and women 17%, and 24% of the amputees were mine victims (ICRC 2011). A cumulative table in the same report lists about 355,000, 339,000, 32,500 and 384,000 items for 1979 to 2010, which I read as prostheses, orthoses, wheelchairs and crutch pairs [VERIFY], because the column order did not survive extraction. In Cambodia the ICRC has worked since 1991, opened Battambang in 1992 and Kampong Speu in 2005, and had supported more than 166,000 people by 2022, about 11,000 a year, half of them mine victims (ICRC 2022). NU-04 gives the Afghan figures and need not be repeated (THRIVING library, NU-04).

The technique is written down (ICRC 2006). The design criteria are that the limb be durable, comfortable, easy to maintain and to learn, standardised, cheap and available. A plaster cast of the stump is taken and corrected "according to best P&O practice", which the manual does not describe. A 6 mm EVA foam liner is heated to about 120 °C and formed over the mould. A 4 mm polypropylene sheet is heated to about 180 °C and drawn over it. Parts are welded at 185 to 200 °C, with at least 2 to 3 mm of polypropylene left under the attachment cup. The limb hangs from a cuff strap above the knee. A SACH foot with a 10 mm heel is fixed with 5 to 8 degrees of outward rotation. The alignment can be moved about 10 mm in every direction. For the bench, a plumb line from the socket falls about 1 cm in front of the axis of the attachment cup [VERIFY my reading of the drawing].

How long does it last? Verhoeff and colleagues followed 43 people in Ho Chi Minh City fitted with polypropylene below-knee limbs between 1993 and 1996 (Verhoeff 1999). Mean use was 33 months at about 9 hours a day. The polypropylene held up, with only two welding faults. The parts that failed were the rubber feet (40 replaced, mean life 8.9 months) and the suspension straps (32 replaced at about 11 months). Seven sockets needed repair or replacement. Eleven limbs (26%) were replaced entirely after a mean of 37 months, and in 64% of replacements poor fit was one of the reasons. Poor fit caused pain in 10 of 15 who reported problems, and six stopped using the limb. Nine people also used older or home-made limbs, often for work. The authors' fixes were simple: give a spare foot at fitting and

use a leather strap.

The inference is that the socket and frame are not the weak point. The foot, the strap and the fit are. A village that can make a strap and a foot, and can re-check fit, will keep an ICRC-type limb going far longer than one that cannot. [VERIFY]

The Jaipur foot. Sethi and colleagues described the foot in 1978 from field trials over 8 years in more than 1,000 amputees (Sethi 1978). It is made of vulcanised rubber over wooden blocks, with a 2 mm hard rubber shell, and was designed for people who squat, sit cross-legged, walk barefoot and work in wet fields. It allows squatting and about 20 degrees of rotation each way, can be washed, and was made in three skin shades. It cost about £2, "as much as a pair of shoes", and some farmers used it for up to 3 years without breakdown (Sethi 1978). The breaking load was about 2 tons, rising to 6 tons once the shell was lined with cord. It was heavier than a SACH foot, and the paint peeled within weeks. An earlier vulcanised limb made in Ceylon by Muller had been judged too heavy and stiff. Arya and Klenerman's review says the foot can be made in about one hour and lets amputees work in wet fields and climb trees (Arya 2008, abstract only). Werner describes the matching Jaipur limb made of sheet aluminium for under US$20, fitted in about one hour once a shop is set up, but needing skill and special equipment (Werner 1987, Other ways).

The record is thinner than the reputation. A three-person gait study found the Jaipur foot had the highest impact force and the SACH foot the best shock absorption, though gait looked "more natural", and called its cosmetic finish and standardisation "far from satisfactory" (Arya 1995). Jensen and Raab followed 81 Jaipur-type feet (41 MUKTI and 40 NISHA) for a median of 16 months and found that 22 (27%) failed and had to be exchanged, mainly from cracking of the rubber skin and slipping between heel layers, though users were nearly all satisfied (Jensen 2006, abstract only). That is a shorter life than Sethi's "up to 3 years" and close to the 8.9 months of the rubber feet in Viet Nam (Verhoeff 1999).

The maker's claims are large. Its operator, BMVSS, claims more than 2.56 million beneficiaries across all devices (BMVSS 2026), and a funder puts the cost at about ₹2,500 to 5,000 a limb (Tata Trusts 2026). Sethi claimed more than 200,000 fitted by 1993 (as cited in Arya 1995). These are vendor and press figures. A 2025 study of a Jaipur camp near Sisophon in Cambodia in March 2023, which fitted 525 people, found that many devices did not meet ISPO standards and that 56% were dissatisfied with fit, 34% with workmanship and 26% with function, measured at delivery and at three months (Heang 2025, search summary only). Three of its authors work for Exceed Worldwide, which runs a competing service, and that should be weighed. Even so, fast camps with no follow-up are the opposite of what Verhoeff's data say a limb needs.

Leather, wood, bamboo and plaster: can a village make a socket without plastic? Yes, on the record of village manuals, though no trial has tested such limbs. Werner's manual gives three methods.

The plaster and bamboo leg was developed by Operation Handicap International in Thai refugee camps (Werner 1987, Plaster and bamboo). A cast is taken over a sponge cup at the stump end, a thick stocking, a plastic bag and thin stockinette, with the bony points marked and the knee slightly bent. While it sets, the maker presses in on both sides of the patellar tendon, the calf and the back of the knee. A waterproof inner socket can be made with water-resistant glue in place of water. The back edge is trimmed no more than ½ cm above the mid-patellar-tendon line. Green bamboo 4 to 6 cm thick, with a node about 2 cm below the stump end, is split into strips about ¾ cm wide, the inner layer removed, and the strips wired round the socket. Five or six layers of glue, sawdust and gauze finish it, a truck-tyre heel is added, and a leather cuff lined with soft leather is riveted slightly behind the midline above the kneecap. A PVC version uses a thick-walled pipe split into four strips and softened by heat.

The leather socket is made from thick firm leather wetted and stretched over a plaster mould, with flat metal side bars and a wooden post (Werner 1987, Other ways). Its advantages are that leather is found everywhere, is cooler than plastic, can be adjusted as the stump shrinks, and corrects small moulding errors by itself. The full manual for it is out of print. The carved wooden socket is the oldest method and the hardest to make well.

A thesis from the University of Malaya tested bamboo as a pylon and found a compressive yield strength of 132.6 MPa and a modulus of 30.7 GPa, with no difference in ground reaction forces from steel in six below-knee users, though it used ASTM tests and not the ISO 10328 standard for limbs (University of Malaya 2012, summary only). A report from Pokhara in Nepal described a local-materials above-knee limb with one serious fault in three years (Prosthet Orthot Int 1998, summary only, authors not seen).

Acceptance is the catch. PROJIMO in Mexico sent a villager to Thailand to learn bamboo limbs, leather sockets and wooden knees, and some "worked very well", but most users rejected them because "they looked too primitive" (Werner 1998). PROJIMO moved to fibreglass and resin, using home-made plaster bandages at about a tenth of the cost of bought ones and second-hand knee joints, and made limbs for under a fifth of the city price. Werner's lesson is that "a good limb is the result of a close working relationship between builder and user" (Werner 1998). He also notes that "on-the-job training for even a few days can make a big difference" (Werner 1987, ch 67).

How fit is checked without a laboratory. The patellar-tendon-bearing socket carries load on the patellar tendon, the inner flare of the tibia, the inner tibial shaft, the outer fibular shaft and the soft front and back muscle masses. It must relieve the tibial crest, the tibial tubercle, the outer tibial flare, the end of the tibia, the head of the fibula with the peroneal nerve behind it, the hamstring tendons and the kneecap (O&P Library Atlas, ch 18). The village check is to walk a few minutes, take the limb off and look. Werner's manual says "an area that looks pale when the limb is removed and then turns red or dark, is a sign of too much pressure" (Werner 1987, Plaster and bamboo). Clinical leaflets agree that redness should fade within 20 minutes of removal (Gillette Children's, undated, OUH, undated, Island Health 2019, Livewell Southwest 2026). Others use 15 minutes (Limbs4Life, undated). This report uses 20 minutes as the safer limit. Pits are scraped where it presses and built up with plaster and glue where it is loose.

When is the stump ready? The sources differ, and the difference is about which limb. WO-09 fits an interim limb as soon as the stitches are out and expects it to last about 2 months (THRIVING library, WO-09). Werner advises a temporary limb first, because the stump shrinks, and a permanent limb after 4 to 6 weeks or when the swelling has gone, with an elastic bandage until then (Werner 1987, ch 67). The O&P Atlas puts interim fitting at about 6 to 10 weeks and definitive fitting when the volume has plateaued, for example a month without needing extra socks, and notes that shrinkage may settle by 4 months but often continues for a year or more (O&P Library Atlas, ch 18). The MSD manual gives 12 to 18 months of volume change (MSD, undated, prosthesis). A Cochrane review found low-certainty evidence that rigid dressings shorten the time to readiness (Kwah 2019, summary only). The working rule in this report is a simple temporary limb at 6 to 12 weeks, a permanent socket only after a month without adding socks, and a new socket expected within the first year. [VERIFY] This is my synthesis.

1.3 Splints, braces and plaster

Splinting. WO-05 covers splinting materials, padding, the Thomas splint and making plaster from gypsum, and its findings stand (THRIVING library, WO-05). Two points from it bear on device making. Nigerian bonesetters' splints of bamboo, palm midrib, bark and cardboard fail at the binding, not the rigid part. And a cast can be stiffened with wood, bamboo or tin strips, and given a walking heel from tyre, hard wood or a 5 cm plaster cube (THRIVING library, WO-05).

Home-made casting material. Werner's manual makes plaster bandage from crinoline or gauze with 8 to 10 holes per cm, starched, with plaster rubbed in and rolled loosely (Werner 1987, ch 61). Up to a third of the plaster is lost in the water. It must be stored airtight. Warm water or salt speeds setting. Alternatives listed are wax cloth, papier-mâché, egg white and flour (India), cassava flour, and clay, which takes several days to dry.

Plaster burns. Plaster gives off heat as it sets. Lavalette, Pope and Dickstein measured setting temperatures and found the risk of burns rose when dip water was above 24 °C and the cast was thicker than 8 ply, and worse still when the limb rested on a pillow while setting (Lavalette 1982, abstract only). Hutchinson and Hutchinson found that thick casts of extra-fast-setting plaster approached dangerous temperatures, again worst when left to set on a pillow

(Hutchinson 2008, abstract and secondary summary only). The two agree on direction. The second did not give one threshold that I could read, so the 24 °C and 8 ply figures rest on one source. [VERIFY] Village plaster made from gypsum will vary in setting speed, so the rule is cool water, thin casts and open air.

Braces from plastic, leather and metal. Werner's plastic brace uses polypropylene sheet 3 mm thick, or 4 to 5 mm for stronger braces, from a 30 by 60 cm sheet, at about US$1 to 2 a brace, heated until it turns clear (Werner 1987, Plastic braces). Makers in Pakistan heated it in a clay pot of coals. The mould needs about three layers of plaster. Bony bumps on the mould are not reduced, so that the brace stands off them. The brace is padded with moleskin, foam, blanket or inner tube. Plastic from buckets, at least 2.5 mm thick and heated in an oven to at least 230 °C, is good only for night braces because it breaks. "Usually after a year or two the plastic 'gets tired' and breaks." Cotton stockings are needed under it, and vents low down are avoided, because sweat causes rashes and fungus. Orthoses were the largest share of the ICRC's output in 2010, at 45,129 (ICRC 2011).

Drop-foot orthoses. The commonest brace a village will need holds up a dropped foot after nerve injury, stroke, leprosy or polio. The plastic ankle-foot orthosis above is the standard. Where there is no plastic, a cord or strap from the front of a shoe to a padded cuff below the knee will lift the toes. [VERIFY] That is my inference, and the cuff must not press behind the head of the fibula, where the peroneal nerve runs. Werner's own childhood experience is a warning. His arch supports caused sprains and his metal braces caused deep sores, and he says to "ask the child at every stage how she feels about an aid" (Werner 1987, ch 56).

1.4 Shoes for the foot that cannot feel

Paul Brand, working at Vellore from 1946 and later at Carville in Louisiana, showed that the hands and feet of people with leprosy are destroyed by injury and infection after pain is lost, not by the disease itself (Leprosy History, undated). He named three mechanisms: continuous low pressure, high impact, and repeated moderate stress. The handbook "Insensitive Feet" was revised by the Leprosy Mission in 1981. I could not confirm that Brand invented microcellular rubber (MCR) insoles, though they are tied to his work [VERIFY].

The record is mixed. Govindasamy and Paul report that ulcers took 42% of admissions and 55% of bed-days at two leprosy hospitals in India in 2019 (Govindasamy 2021). An MCR insole of Shore hardness 15 to 20 spreads the contact area, but its effect on peak pressure has not been measured. Adding simple orthoses (a tarsal platform, metatarsal pads, a Hathi pad) to MCR healed 57% of ulcers against 12.5% with MCR alone over 7 months. In diabetes, a small Italian trial of 69 people found re-ulceration at one year of 27.7% with therapeutic shoes against 58.3% with ordinary shoes (Uccioli 1995). A larger American trial of 400 diabetic veterans without severe deformity found ulcers in 15% with cork insoles, 14% with prefabricated insoles and 17% of controls, with no significant difference, and concluded that "careful attention to foot care" might matter more (Reiber 2002, abstract read). The WHO standards give a 12 to 15% lifetime chance of a foot ulcer in diabetes (WHO 2017).

The inference is that shoes help most for the foot that has already ulcerated or is deformed, and that daily inspection is the core of the protection. [VERIFY] A village shoe for the numb foot needs a firm outer sole that a thorn cannot pierce (tyre rubber), a soft insole that can be replaced (MCR if salvaged, otherwise felt, cork or folded cloth), no nails or seams on the inside, and room for the toes.

1.5 Wheelchairs and cushions

The record of donated chairs. The WHO guidelines report an Indian study in which 60% of users of donated chairs stopped using them because of discomfort and unsuitability (WHO 2008, citing Mukherjee and Samanta 2005). Hospital-style chairs are built for temporary use indoors and break on rough ground. In Sri Lanka, Motivation found that 75% of people admitted with spinal cord injury in 1997 died within 18 to 24 months of complications, and that with training and good chairs with cushions, pressure sores fell by 71% and repeat urinary infections by 61% within two years (WHO 2008, citing Beattie and Wijayaratne). The WHO guidelines state that "an inadequate

pressure-relief cushion is the one component of a wheelchair that is most likely to cause pressure sores, serious injury or premature death". The cushion should be removable and washable. The rest of the cushion question belongs to NU-09.

Hotchkiss and Whirlwind. Ralf Hotchkiss, paralysed in a 1966 motorcycle accident, built chairs with users in Nicaragua, where he saw up to five people sharing one chair, and published Independence Through Mobility in 1985 (Wikipedia, Ralf Hotchkiss). The RoughRider is built from 7/8 inch steel tube, weighs about 40 lb, has a long wheelbase and wide front casters, and uses bicycle-shop tyres (Wikipedia, RoughRider). It was developed with users in more than 40 countries since 1980, and Whirlwind claims 60,000 riders (Whirlwind, undated). I found no independent evaluation.

Motivation. David Constantine and Simon Gue designed a chair in a 1989 Royal College of Art competition, built it in Dhaka, and founded Motivation in 1991 (University of Bristol, undated, search summary). In 1993 they made a three-wheeled wooden chair, the Mekong, in Cambodia. I could not read Motivation's own data.

What a village carpenter and smith can build. Werner's manual gives six designs (Werner 1987, ch 66). The HEALTHLINK wooden chair "can be built in one day by someone with some carpentry skill", but has a single rear caster and tips over. A plywood chair with 20-inch bicycle wheels and two front casters is within a carpenter's reach, but plywood that is not marine grade comes apart when wet and bicycle axles bend. A square-tube chair can be bolted, with welding needed only for the front wheels. A rebar and woven plastic chair needs welding. The Whirlwind folding chair needs tube bending, welding and spoking. A lying-board chair serves people who cannot sit. Werner adds that the seat must suit the ground, with large front casters for kerbs and rocks and wide tyres for sand, that numb buttocks need special cushions and changes of position, and that too much support "may actually slow down her progress" (Werner 1987, ch 64).

The simplest chair a village can rely on is a four-wheeled wooden chair on two salvaged bicycle wheels and two casters, with the seat set so that the user's weight sits just in front of the rear axle, plus a cushion. [VERIFY] This is my judgement from Werner's designs, and the three-wheeled Mekong pattern is the alternative where rough ground matters more than turning indoors.

1.6 Crutches, frames, sticks and the cane

Crutches. Werner places the top of an underarm crutch three fingers' width below the armpit and the handgrip about a third of the way down, so the elbow is slightly bent (Werner 1987, Crutches). The MSD manual says 2.5 to 5 cm (two to three fingers) below the armpit, the elbow bent 15 to 30 degrees, and the tips 5 cm to the side and 15 cm in front of the toes (MSD, undated, crutches). The two agree within a finger. Both warn that weight must go through the hands. Bearing weight in the armpit "can cause nerve damage", with numbness and weakness of the hands (Werner 1987, Crutches), and MSD names compression of the axillary nerve and artery and radial nerve palsy. For stairs, the good leg leads going up and the crutches lead going down. A nursing source gives the length as from the armpit fold to the sole plus 5 cm (Orthopaedic Nursing 2018).

Werner's designs include a forked branch padded with kapok, a crutch of wooden dowels 2.5 to 3.5 cm thick (the Huckstep design), and a crutch of reinforcing bar from 6.5 mm to 1.6 cm, with tips cut from tyre rubber and extra-wide tips for sand. Walking poles for a child should be taller than the child to protect the eyes. The progression runs from parallel bars to a wheeled walker, a crutch-walker, underarm crutches, elbow crutches, a wide-based cane, a stick and finally no aid (Werner 1987, ch 63). Parallel bars can be made of bamboo, wood or pipe.

The long cane. The long white cane and its technique were developed at Valley Forge Army Hospital in 1944 by Sergeant Richard Hoover. It was lighter and longer than earlier wooden canes and was swung in an arc in front of the trailing foot (VA Hines 2023). The usual length reaches between the breastbone and the chin (RNIB, undated). A study by Rodgers and Wall Emerson found that a cane reaching the breastbone detected drop-offs better than canes

5 to 15% shorter or 10 to 20% longer (as cited in PMC3994889). The technique needs teaching. A straight stick of the right length, with a smooth tip, will do. CH-08 does not cover the cane, so it is placed here.

1.7 Hearing

The ear trumpet was sold commercially by Rein of London from about 1800 (Wikipedia, History of hearing aids). A popular article claims passive trumpets give 10 to 25 dB of gain (NoTech 2017), but it cites no measurement, and I could not read Stephens and Goodwin's history of non-electric aids [VERIFY]. A cone of tin, horn or rolled bark with a narrow end in the ear, or a speaking tube, is a fair village substitute, and the cheapest aid is a speaker who faces the listener and talks slowly.

Electronic hearing aids will fail when their batteries run out. Zinc-air cells keep about 3 to 4 years sealed. Once the tab is pulled, size 10 lasts up to about 10 days, size 312 about 12, size 13 about 14 and size 675 about 20 (Beltone, undated). Leaving the cell for about a minute after removing the tab lets it reach full voltage. A village should hoard sealed cells, keep them cool and dry, and give priority to children learning to speak. [VERIFY] Spectacles are in CH-08.

2. Evidence grades

Grades: A, strong (several good trials or a firm meta-analysis). B, moderate. C, weak or observational, including field series and manuals. D, tradition or expert opinion only. X, evidence of no effect or of harm.

Practice	Tradition or claim	Record	Grade
Polypropylene below-knee limb lasts about 3 years	ICRC design aims	One cohort of 43, mean 37 months to replacement	C
Rubber foot lasts years	Sethi, up to 3 years	27% failed by 16 months, mean life 8.9 months in Viet Nam	C
Jaipur camp fitting gives good limbs	Vendor claims of millions served	56% unhappy with fit at one camp	C
Village leather, bamboo or plaster socket works	Werner, Handicap International	Manuals and field reports, no trial	C
Bent-knee peg for long-term use	Old practice	Causes fixed bent knee	X
Definitive socket only when volume is stable	P&O practice	Expert consensus	C
Redness fading within 20 minutes as fit test	Clinical leaflets	Consensus, 15 minutes in some	D
Cool dip water and thin casts prevent burns	Orthopaedic teaching	Two laboratory studies	B
Therapeutic shoes for the numb or diabetic foot	Brand, leprosy services	One small RCT for, one large RCT against	B
Orthoses added to MCR footwear heal ulcers	Leprosy services	Observational, 57% against 12.5%	C
Donated hospital-style wheelchairs	Charity practice	60% stopped using them	X
Training plus good chair and cushion	Motivation	Before and after, sores down 71%	C

Practice	Tradition or claim	Record	Grade
Rough-terrain chairs (Whirlwind)	Maker's claims	No independent evaluation found	D
Crutch weight on hands, not armpit	Manuals	Nerve injury well described	B
Long cane at breastbone height	Hoover, RNIB	One study	C
Ear trumpet gain of 10 to 25 dB	Popular article	No primary measurement found	D

3. Means ledger

Rung	What device making looks like	What the rung changes
Hands	Measuring a stump, checking skin after 20 minutes, teaching crutch use, guiding a blind person, the bent-knee peg as a short stopgap.	Fit checks and teaching prevent most harm, and need nothing but attention.
Hearth	Forked branch crutches, a straight stick or cane, cloth padding, tyre-rubber tips, cord-and-cuff foot lift, cone ear trumpet, felt or cloth insoles.	A person can walk on crutches within days and a blind person can move alone.
Garden and still	Willow, ash or bamboo for crutches, frames, bars and pylons. Leather from the tanner. Starch for plaster bandage. Glue from hides.	Leather and bamboo make a full below-knee limb possible without plastic.
Village dispensary	Plaster from burnt gypsum, a carpenter for chairs and bars, a smith for side bars and rebar crutches, salvaged bicycle wheels, tyre soles, a record of devices and their due dates.	Plaster casts make a socket fit. The record makes repair happen on time.
District infirmary	A limb and brace workshop with an oven or coal pot for polypropylene and an EVA liner, a welding torch, a stock of feet and straps, a fitter who visits villages.	Polypropylene limbs and braces of ICRC type, and the repair cycle that keeps them in use.
Hospital before the Fall	Prosthetists, CAD/CAM sockets, energy-storing feet, powered chairs, digital hearing aids.	Better comfort and range, but the users in this report's studies did well with far less.

4. Harm test

Pressure sores and skin breakdown. The numb foot in a stiff shoe, the brace on a numb leg, the socket that presses the fibular head, and the wheelchair without a cushion all cause sores. In Sri Lanka most deaths after spinal cord injury came from such complications (WHO 2008). The rule is to look at the skin after every new device and every change.

Pain and abandonment. In Viet Nam poor fit caused pain in two of three who had problems and six people stopped using their limbs (Verhoeff 1999). In India 60% of donated wheelchairs were set aside (WHO 2008). In the Civil War many veterans took cash rather than a limb (Prechtel-Kluskens 2014). An abandoned device is wasted labour.

Falls. A wheelchair with one rear caster tips (Werner 1987, ch 66). A loose crutch tip slides on wet stone. A long cane that is too short gives late warning of a drop (RNIB, undated). A limb that is too long throws the body sideways, so Werner makes it the same length or slightly shorter.

Nerve injury. Weight in the armpit damages the nerves to the arm (MSD, undated). A cuff or strap pressing behind the fibular head can cause foot drop. [VERIFY]

Burns. Plaster dipped in warm water, applied thick, and left to set on a pillow can burn (Lavalette 1982, Hutchinson 2008). Hot polypropylene at 180 °C and heated rubber burn the maker.

Infection. A socket or brace worn over a wet or broken stump traps sweat. Plastic braces cause rashes and fungus without cotton stockings (Werner 1987, Plastic braces).

The aid that keeps a person from walking who could. A wheelchair given to someone who could walk on crutches, or a brace kept on when the muscles have recovered, weakens the person. Werner warns that too much support can slow progress (Werner 1987, ch 64). The bent-knee peg fixes the knee in a bend (Werner 1987, ch 67). Each device needs a review date and a question: does this person still need it?

5. Red flags

Take the device off and seek help at once if any of these appear.

1. Redness that has not faded 20 minutes after removing a limb, brace or cast.
2. A blister, open wound, or black or blue skin anywhere under a device.
3. Swelling, heat or pus at the stump, or a stump that suddenly no longer fits.
4. Numbness, tingling or weakness in the hand of a crutch user, or a new foot drop in a brace or limb user.
5. Pain, burning or heat under a setting plaster cast. Cut it open.
6. A crack in a socket, a split bamboo strip, a loose rivet or a frayed strap.
7. A wheelchair that tips when the user leans back or reaches forward.
8. Any wound on a foot that cannot feel. It needs rest from walking, not a new shoe.
9. A child whose limb or brace no longer fits after a growth spurt.

6. The case against

Appropriate technology is not the same as appropriate care. Harkins, McGarry and Buis reviewed prosthetic and orthotic services in low-income countries and found the research limited and variable, so that the best service model could not be judged (Harkins 2013). In one Nigerian survey 27% of amputees did not use their prosthesis. There is no pooled abandonment rate. The cheap limb is easy to praise and hard to evaluate.

The Jaipur story is partly marketing. Sethi's work was real and his foot answered a real need. But the millions served are the maker's numbers, Jensen and Raab found a 27% failure rate within 16 months, and Heang and colleagues found 56% dissatisfied with fit after a fast camp (Jensen 2006, Heang 2025). The critics in the second study had a competing interest. The first did not.

Users do not want primitive limbs. PROJIMO's users rejected bamboo and leather legs as "too primitive" (Werner 1998). Civil War veterans often preferred cash (Prechtel-Kluskens 2014). A village that offers only a peg may find it left by the door.

Shoes may matter less than care. Reiber's trial found therapeutic insoles no better than usual footwear in people who were already well cared for (Reiber 2002). A village may spend scarce rubber on shoes and neglect daily

inspection.

Charity chairs do harm. Mukherjee and Samanta's finding that 60% of donated chairs were abandoned argues against accepting whatever is offered (WHO 2008).

Fitting is the hard part, and the manuals skip it. The ICRC manual says casting and correction are done "according to best P&O practice" and does not teach them (ICRC 2006). Verhoeff found fit, not material, behind most replacements (Verhoeff 1999). A village can copy the materials and still fail at the skill.

My answer to these critics is that they argue for follow-up, repair and training, not against local making. [VERIFY]

7. 10-line summary

1. About 1 in 200 people needs a limb or brace and about 1 in 100 a wheelchair (WHO 2017, WHO 2008).
2. A below-knee socket can be made from plaster and bamboo or from leather on a plaster mould, with no plastic.
3. The fit, the foot and the strap fail first, not the socket (Verhoeff 1999).
4. Rubber feet last about 9 to 16 months in use, not the years claimed (Verhoeff 1999, Jensen 2006).
5. Check skin after every fitting: redness must fade within 20 minutes.
6. Fit a simple temporary limb at 6 to 12 weeks and a permanent socket only when the stump stops shrinking.
7. Never use a bent-knee peg for more than a short time.
8. Plaster: water no warmer than 24 °C, no more than 8 layers, never set it on a pillow.
9. A wheelchair without a good cushion is dangerous. Donated hospital chairs are often abandoned.
10. Crutch weight goes on the hands. The cane reaches the breastbone.

8. Open questions

1. How long do leather and bamboo sockets last in daily village use? No study was found.
2. Does a straight peg outlast a footed limb, as WO-09 says? No data were found.
3. What is the true lifespan of a Jaipur foot beyond 16 months?
4. Which home-made insole material comes closest to MCR in pressure relief?
5. How many hours of training make a village limb maker safe? Werner says a few days of on-the-job training helps, but gives no figure.
6. How much gain does a passive ear trumpet give?
7. [OWNER] Should a village amputate only when it can make a limb, or regardless? WO-09 advises leaning towards salvage in the arm.
8. [OWNER] Should a village accept donated hospital wheelchairs?
9. [OWNER] Should leather or bamboo be the village default for sockets?

9. Sources to read in full

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10. At the bedside after the Fall

Household. Minimum viable version: crutches made to size from a forked branch or dowels with tyre-rubber tips, a cane for the blind person cut to the breastbone, a cone trumpet for the deaf, and daily skin checks of every numb foot and stump. What it needs to start: a knife, a saw, tyre rubber, cloth padding, and one person who knows the sizing rules. First failure to expect: weight carried in the armpit, or a numb foot with an unseen wound.

Village of 300. Expect one or two people who need a limb or brace and about three who need a wheelchair. [VERIFY] Minimum viable version: a carpenter who can build a four-wheeled wooden chair with bicycle wheels and a cushion, a smith who can make side bars and rivets, a supply of plaster from burnt gypsum, and one person trained to take a stump cast and check fit. A notebook lists each device, its owner and its next check. What it needs to start: gypsum, starched cloth, bamboo or leather, bicycle wheels, tyres. First failure to expect: a limb made too soon, before the stump has shrunk, and then left unused.

District of 3,000. Expect about 15 people needing a limb or brace and 30 needing a chair. [VERIFY] Minimum viable version: a workshop that can thermoform polypropylene and EVA, a stock of spare feet and straps, a fitter who visits each village every three months, and training for village makers. What it needs to start: polypropylene sheet or salvaged plastic, an oven, a welding torch, a plaster supply, rubber for feet. First failure to expect: feet and straps wear out in a year and no spares come.

11. Protocols

These protocols combine the manuals cited above. Where a figure is my own choice it carries [VERIFY]. The stump's care before fitting is in WO-09 and the training to walk is in NU-04, Protocol 3.

Protocol 1: Measuring and casting a below-knee stump

1. Wait until the wound is healed and the stitches are out. For a permanent socket, wait until the stump has needed no extra sock for a month (O&P Library Atlas, ch 18).
2. Sit the person with the knee bent slightly. Mark with charcoal or ink: the kneecap, the patellar tendon, the tibial crest, the tibial tubercle, the head of the fibula, the end of the tibia and any tender point.
3. Measure with a cloth tape: the circumference just below the kneecap and every 5 cm down to the end, the length from the middle of the knee to the end of the stump, and from the middle of the knee to the heel of the other leg (Werner 1987, ch 67). Write them in the device book.
4. Cover the stump: a sponge cup at the end, a thick stocking, a thin plastic bag, thin stockinette (Werner 1987, Plaster and bamboo).
5. Dip plaster bandage in water no warmer than 24 °C and squeeze it (Lavalette 1982). Wrap 4 to 6 layers, never more than 8. [VERIFY layer count for a socket mould]
6. While it sets, press in with the fingertips on both sides of the patellar tendon, firm the calf and the back of the knee. Keep the knee still. Hold it in the air, not on a pillow.
7. Remove when firm, after about 10 to 15 minutes. [VERIFY] Fill it with plaster to make the positive mould.
8. On the mould, build up plaster over the relief areas (tibial crest, tubercle, end of tibia, fibular head) by 2 to 3 mm so the socket will stand off them. Shave 2 to 3 mm off the load areas (patellar tendon, inner tibial flare, calf). [VERIFY amounts]

Protocol 2: A bamboo and plaster or leather below-knee limb

1. Make the inner socket on the mould, either in plaster bandage set with water-resistant glue, 5 or 6 layers of glue, sawdust and gauze, or in thick firm leather wetted, stretched over the mould and left to dry (Werner 1987, Plaster and bamboo, Other ways).

2. Trim the back edge no more than ½ cm above the mid-patellar-tendon line. Leave the front high enough to cover the patellar tendon.
3. Cut green bamboo 4 to 6 cm thick with a node about 2 cm below the stump end. Split the upper part into strips about ¾ cm wide, remove the soft inner layer, and wire the strips round the socket.
4. Set the length equal to the other leg or 1 cm shorter. Set the foot or peg end turned out 5 to 8 degrees, as the ICRC sets its foot (ICRC 2006).
5. Finish with a truck-tyre sole and heel about 10 mm thick at the heel.
6. Make a leather cuff lined with soft leather, riveted slightly behind the midline at each side and buckled above the kneecap.
7. For a straight peg, end the bamboo or wood in a rubber tip 4 to 5 cm wide. [VERIFY] Never make a bent-knee peg except as a stopgap for a few weeks. [OWNER] Whether the village forbids the bent-knee peg outright or allows it as a stopgap is the owner's rule.

Protocol 3: Fitting and skin checks

1. First walk: 5 minutes between bars or with a helper. Remove the limb. Look at the whole stump in good light.
2. Pale skin that turns red or dark marks too much pressure (Werner 1987, Plaster and bamboo). Time the redness. It must fade within 20 minutes (Gillette Children's, undated, Island Health 2019).
3. If it does not fade, scrape the socket over that point. Where the stump moves loosely, build up with plaster and glue or leather.
4. Day 1: 3 sessions of 15 minutes. Add 15 to 30 minutes a session each day while the skin stays clear. [VERIFY]
5. Look twice a day for a month and after every change of socks. On numb skin, look after every hour of wear. [VERIFY]
6. Add a sock when the socket goes loose. Count the socks. When three or more are needed, make a new socket. [VERIFY]
7. Stop at once for any red flag in section 5.

Protocol 4: Maintenance schedule for a limb

When	What
Daily	Wash and dry the stump and socket. Check skin. Look for cracks.
Weekly	Check the strap, rivets, wire, and heel rubber.
Every 3 months	Fitter's visit. Re-measure the stump. Check alignment and length.
About 9 months	Expect to replace a rubber foot (Verhoeff 1999). Keep one spare foot per user.
About 11 months	Expect to replace the strap. Leather is easier to repair (Verhoeff 1999).
Every 6 months in a child	New socket or limb as the child grows (THRIVING library, WO-09).
About 3 years in an adult	Expect a new limb (Verhoeff 1999, Prechtel-Kluskens 2014).

[OWNER] When spare feet and straps run short, the village must decide who gets them first: those who work the fields, children, or those fitted longest.

Protocol 5: Making and fitting crutches

1. Start with the length from the armpit fold to the sole of the shoe plus 5 cm (Orthopaedic Nursing 2018). Then adjust standing: the top sits two to three fingers (2.5 to 5 cm) below the armpit with the tips 15 cm in front of and 5 cm to the side of the toes (MSD, undated, crutches, Werner 1987, Crutches).
2. Place the handgrip so the elbow is bent 15 to 30 degrees.
3. Use straight-grained hardwood 2.5 to 3.5 cm thick or a forked branch. Pad the top and grip with cloth or kapok. Fit tyre-rubber tips, wide ones for sand.
4. Teach: weight on the hands, never the armpit. Going up, the good leg first. Going down, the crutches first.
5. Check hand numbness weekly. If present, shorten the crutch or switch to elbow crutches.

Protocol 6: The long cane

1. Cut a straight light stick to reach between the breastbone and the chin (RNIB, undated).
2. Smooth the tip or fit a rounded wooden or rubber end.
3. Teach the arc: tip swept from side to side, a little wider than the shoulders, touching in front of the foot that will step next (VA Hines 2023).
4. Check the length again if it fails to warn of steps.

Protocol 7: A village wheelchair and cushion

1. Measure the user sitting: hip width plus 2 to 3 cm for seat width, back of buttock to back of knee less 3 to 5 cm for depth. [VERIFY]
2. Build a four-wheeled chair: hardwood or marine-ply frame, two 20-inch bicycle wheels at the back, two casters at the front, never a single rear caster (Werner 1987, ch 66).
3. Check tipping: the user leans back and reaches forward with a helper behind. If it tips, move the rear wheels back.
4. Give a cushion with a washable cover. Teach the user to lift or lean every 15 to 30 minutes. [VERIFY] Cushion design for the paralysed is left to NU-09.
5. Review at 1 month and every 3 months. Ask whether the person could walk with crutches instead.

Protocol 8: A drop-foot orthosis

1. Take a plaster cast of the lower leg and foot with the ankle at a right angle, 3 layers, cool water.
2. Heat polypropylene 3 mm (4 to 5 mm for a heavy adult) until clear and draw it over the mould (Werner 1987, Plastic braces).
3. Trim behind the calf and over the sole. Pad over the ankle bones and the fibular head.
4. Wear with a cotton stocking. Check the skin after the first hour and then daily.
5. Without plastic: a cord from the shoe front to a padded cuff below the knee, clear of the fibular head. [VERIFY]
6. Replace when the plastic cracks, often after one to two years.

12. Numbers to carry

Item	Number	Source
Need for a limb or brace	About 0.5% of people	WHO 2017
Need for a wheelchair	About 1% of people	WHO 2008
Users per trained fitter	300 to 600 a year	WHO 2017
Skin redness after removal	Must fade within 20 minutes (15 in some)	Gillette, Limbs4Life

Item	Number	Source
Temporary limb	6 to 12 weeks after amputation	This report's synthesis [VERIFY]
Permanent socket	After a month with no extra socks	O&P Atlas
Stump volume change	Up to 12 to 18 months	MSD
Plaster dip water	No warmer than 24 °C	Lavalette 1982
Plaster cast thickness	No more than 8 ply	Lavalette 1982
Plaster from gypsum	120 to 150 °C for 1 to 2 hours	WO-05
Polypropylene sheet	180 °C, 4 mm socket, 3 to 5 mm brace	ICRC 2006, Werner
EVA liner	120 °C, 6 mm	ICRC 2006
Rubber foot life	About 9 months (Viet Nam), 27% failed by 16 months	Verhoeff 1999, Jensen 2006
Strap life	About 11 months	Verhoeff 1999
Polypropylene limb life	Mean 37 months	Verhoeff 1999
Crutch top	2.5 to 5 cm below armpit, elbow 15 to 30°	MSD
Cane length	Breastbone to chin	RNIB
Zinc-air cell, sealed	3 to 4 years	Beltone
Donated chairs abandoned	60%	WHO 2008

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