# Benevolent Patent Extensions:
# A New Policy Instrument To Induce Impact Investment

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Research and development (R&D) investments can generate technological breakthroughs that rapidly produce enormous societal gains. For example, the US government's Biomedical Advanced Research and Development Authority (BARDA) directly invested $19 billion in assistance to develop and produce COVID-19 treatments and vaccines over less than a year after the pandemic began, generating a range of vaccines and treatments that enabled the world to get a nearly unprecedented pandemic somewhat under control and avert millions of preventable deaths (CBO 2021). BARDA also made advanced purchase commitments (APCs) with six manufacturers, guaranteeing them an adequate post-discovery sales market to justify considerable private investment in R&D above and beyond BARDA's direct public investment. It is plainly feasible to mobilize major funding for highly impactful R&D to address major societal challenges.

Yet scant R&D expenditures target neglected tropical diseases (NTD, e.g., dengue fever, schistosomiasis), rare genetic disorders (e.g., Down's syndrome), or the productivity and resilience of orphan crops (OC, e.g., cassava, millet, sorghum) that affect the lives and livelihoods of an estimated 3.2-4.5 billion persons – roughly half the world's population (see Supplementary Materials for detailed, rough estimates). The estimated historical economic return per dollar invested on such R&D is very high, in the range $17-27 for on NTDs (Fitzpatrick et al. 2017; Redekop et al. 2017) and $10 for staple crops for the low-income tropics (Alston et al. 2022). Such high returns clearly signal underinvestment.

Adequate investible capital exists but remains on the sidelines. US corporate cash on hand totaled $2.7 trillion in early 2022 (Krantz 2022) earning negligible or negative returns, given prevailing inflation and interest rates. That is two orders of magnitude greater than the combined estimated annual investment required to largely eliminate global hunger – $26 billion (Laborde et al. 2020) – as well as five major NTDs – another $1 billion (Fitzpatrick et al. 2017).

The failure to invest plentiful private capital in solving high social impact problems that affect roughly half the world's population arises largely due to insufficient financial incentives for discoveries to address these challenges. Long R&D timelines and high risk of failure in any given research initiative discourage R&D investments. Plenty of private agricultural and biomedical R&D investment nonetheless occurs despite these obstacles. The real issue is the ultimate commercial market size and investors' ability to capture a sufficient share of the social returns to technological advances. The core problem is that innovators capture only about 4 percent of the total social surplus created by innovation (Nordhaus 2004).

R&D effort therefore responds strongly to commercial market size (Agarwal and Gaule 2022). But the 240 million persons affected by schistosomiasis, for example, are very poor and uninsured, and therefore not a lucrative market for biomedical companies. The world needs policy innovations that make it lucrative to invest private R&D funding to solve the problems poor people face.

This article proposes a new policy instrument – benevolent patent extensions (BPEs) – to complement existing tools to induce private R&D investment in high social impact domains, like NTDs and OCs. Instruments such as prizes, APCs, impact investment, humanitarian use licensing, or priority review vouchers (PRVs) are helpful but insufficient. Further, each suffers

some shortcomings that BPEs can help overcome as the world expands the portfolio of policy and institutional innovations to leverage private capital to solve societal problems.

**The Existing R&D Encouragement Toolkit**

Several tools exist to encourage private R&D on major social problems. Collectively, these have proved woefully insufficient.

Prizes and APCs are the main, well-established tools used to induce private investors to undertake R&D on specific problems.[1] Since at least the 18th century, when European governments offered prizes to encourage inventors to develop solutions to problems such as food preservation and nautical navigation, organizations have tried to encourage private R&D with the promise of a substantial, future lump sum award for a discovery that satisfies pre-specified criteria. Ideally, the prize is calibrated to equal the expected fixed costs of the discovery, so that the inventor can then just charge individual or institutional buyers for the variable costs of producing the invention. APCs modify that idea slightly by offering not a lump sum prize but instead a guaranteed price per unit delivered and purchase volume, thereby ensuring the discovery a minimum market size that covers both fixed and variable costs at some minimum scale necessary for commercial viability.

APC and prize financing falls largely to philanthropic, multilateral and bilateral donors in the high-income countries (HICs), through efforts like GAVI, the Vaccine Alliance, or AgResults. The reason is that low-and-middle-income country (LMIC) governments generally lack fiscal resources to undertake APCs the way the US government did for COVID-19 treatments and vaccines or to offer prizes substantial enough to induce substantial private R&D expenditures. APCs have generated outstanding returns, for example developing three pneumococcal vaccines that immunized 150 million children, saving an estimated 700,000 lives (Kremer et al. 2020).

Impact investment aims to generate measurable social or environmental benefits along with competitive financial returns. The global impact investment market has risen rapidly, encompassing as much as $2.3 trillion at end-2020, roughly three-quarters of it publicly managed (Volk 2021). In some cases, including benefit corporations that legally commit shareholders to environmental and social, as well as financial, performance goals, impact investing taps private investors' valuation of the non-financial impacts of a venture, perhaps trading off some financial returns for measurable gains in other domains. In most cases, however, impact investing operates rather like prizes and APCs by offering a financial reward for improved outcomes. Often this comes in the form of a commitment to share future costs reductions that a discovery might cause. An impact bond for R&D investment in a NTD vaccine,

[1] Kremer and Glennerster (2004) lay out the logic of APCs – which they label advanced market commitments (AMCs). The idea was subsequently refined and advanced by Barder, Kremer, and Levine (2005), Berndt et al. (2007), and Kremer, Levin, and Snyder (2019), among others. Masters (2005), Kalil (2006), Moser and Nicholas (2013), Bhattacharya (2021), and Graff-Zivin and Lyons (2021) all discuss the structure and impacts of prizes used to induce innovative activity.

for example, might provide up-front R&D financing in exchange for future repayments that increase conditional on savings enjoyed from prospective reductions in future mass drug administration expenses for curative care.

Prizes, APCs and impact investing nonetheless suffer a few shortcomings. First, private investors in R&D might reasonably doubt whether future government or philanthropy leaders will honor predecessors' past commitments. A time inconsistency problem arises if prospective innovators fear a change of governments or a steep fall in a foundation's endowment might imperil future promised payments or if investors fear that the measures used to trigger supplemental payments may prove unreliable. Second, governments and philanthropies have limited capacity to raise the funding necessary to make credible commitments. Third, the global public good nature of discoveries like vaccines against NTDs or improved OC germplasm create a free-rider problem. Prizes, APCs and impact investing offer valuable tools to induce private R&D investment in NTDs and OCs but remain insufficient.

Intellectual property (IP) rights offer a different strategy for inducing private R&D investment. Government protection of IP embodied in patents, trademarks, etc. assures an inventor's monopoly power over a non-obvious, novel, useful discovery for a period in exchange for making the details publicly available, thereby facilitating adaptative and combinatorial discovery. IP thus works quite differently from prizes, APCs and impact investing all of which pre-commit some form of payment from the coordinating organization. IP instead empowers the innovator to extract consumer surplus from future customers through monopoly pricing, obviating the need for additional government appropriations or philanthropic donations. BPEs leverage IP, but in a fundamentally different way than two existing IP-based methods do.

Humanitarian use licensing (HUL) ensures technology access on a royalty-free or heavily discounted basis to certain classes of individuals or organizations – e.g., those in LMICs (Brewster er al. 2005; Lybbert and Sumner 2012). The IP holder can still extract monopoly profits from other users of the protected technology. HUL can be very effective for neglected markets, for example in making HIV/AIDS or cancer treatments available and affordable to LMIC patients. But HUL works when there exists a commercial market of sufficient scale to which the discount does not apply, thereby making the R&D investment financially attractive. The model does not work well for NTDs, OCs and other challenges relatively specific to low-income populations and may not even work well for more global agricultural technologies – e.g., maize, rice or wheat germplasm – due to technology mismatch problems across varied agricultural and disease ecologies (Stewart 1978; Basu and Weil 1998; Acemoglu and Zilibotti 2001).

Priority review vouchers (PRVs) incentivizes research into NTD and rare diseases by awarding successful applicants for new treatments a voucher that accelerates regulatory review of some other drug (Ridley et al. 2006; Ridley and Régnier 2016). PRVs can be retained or sold, with observed values as high as US$350 million (Kerr et al. 2018). But PRVs' value is intrinsically capped by the reduced review duration, typically measurable in months, and by the limited

application domain. The US FDA program presently applies to only 27 diseases[2] and a PRV could never apply to a discovery not subject to FDA review authority. Perhaps as a result, it remains unclear whether PRVs have induced additional marginal investment in R&D in those diseases since FDA began issuing PRVs in 2009 (Kerr et al. 2018; Hwang et al. 2019).

Each of these tools can and does play a role. But even cumulatively, APCs, prizes, impact investing, HULs and PRVs remain woefully insufficient. Vast unmet demand remains for R&D to address challenges faced almost solely by the world's poor and necessitates new policies to encourage expanded public and private R&D investment.

**Benevolent Patent Extensions: A New Tool**

The story of elfornithine illustrates the potential and need for BPEs and the limitations of IP-based strategies to induce R&D for NTDs, OCs and other challenges the poor face. Elfornithine was first developed as a cancer treatment but proved ineffective. But it proved incredibly effective as a treatment for advanced trypanosomiasis, so-called 'sleeping sickness' (Pepin et al. 1987, Milord et al. 1992), inducing the World Health Organization to add eflornithine to its Essential Medicines List. The patent-holder (Aventis) stopped producing eflornithine in 1995, however, because its limited commercial market made the drug unprofitable. Production of eflornithine for treating sleeping sickness nonetheless resumed after several years' unavailability following the discovery that a cream formulation of the drug was effective in removing unwanted facial hair on women (Wolf et al. 2007). A drug that saves tens, perhaps hundreds of thousands of lives, could only emerge as a serendipitous discovery in pursuit of a lucrative cancer treatment, and could only remain in production once a lucrative market could be found in HICs for a luxury product inessential to a healthy and active life.

The eflornithine lesson is to tap the profit potential of luxury inessentials targeted for well-off consumers to induce the discovery and delivery of advances that materially improve the lives of the poor. When filing for a patent on a "benevolent discovery", an inventor could request a benevolent patent extension (BPE) that confers the right to extend the patent of some other, 'non-essential' IP conditional on the inventor (i) attesting it will not enforce its patent right or dedicating to the public the terminal part of the patent term (e.g., per 35 United States Code §253(b)) – a "public use" condition – and (ii) the BPE holder ensures production and distribution of the benevolent discovery for a minimum period of time (e.g., ten years) – an "assurance of availability" condition.

Let me explain the basic intuition before defining these key terms. The BPE replaces the (meager) direct market value of a benevolent discovery with the value of the non-essential patent's extension. Many non-essential patents generate profits of hundreds of millions of dollars annually. The considerable value of a perhaps as much as a few years' extended patent protection on, for example, lucrative business software or a device for nonemergency plastic surgery or male pattern baldness treatment, would thus become the value of an effective

[2] As of July 4, 2022, per the official listing at https://www.fda.gov/about-fda/center-drug-evaluation-and-research-cder/tropical-disease-priority-review-voucher-program.

treatment for schistosomiasis or for a successful variety of drought-resistant cassava for which little commercial market exists. The newfound profit potential in R&D on NTDs, OCs, and similar challenges mainly faced by the world's poor would induce substantial new private investment. And by requiring non-enforcement or public dedication of the new IP, as well as production and distribution of the benevolent discovery (by the inventor or a licensee), the BPE would ensure availability of benevolent discoveries.

The definition of "benevolent discovery" is crucial. The discovery would have to satisfy not only the usual patent criteria – non-obvious, novel and useful – but also a benevolence standard that the discovery would be reasonably expected to significantly improve the lives or livelihoods of at least thousands of people whose poverty implies that an investor could not reasonably expect to earn a profit from the discovery. That is, the direct aim of a benevolent discovery is to relieve suffering, not to make a profit. Existing patent incentives do not elicit many benevolent discoveries. Most arise from philanthropic or public R&D investments that compel making the discovery freely available, at least to non-profit users. The BPE renders the benevolent discovery profitable and thus attractive to private investors.

The BPE renders the benevolent discovery profitable by extending the life of 'non-essential' IP, i.e., a design, good or process that does not safeguard a healthy and active life. A huge number of lucrative discoveries are non-essential, encompassing business software, designs, entertainment, lifestyle products, and elective biomedical treatments. There exists considerable, lucrative nice-but-inessential IP in, for example, male baldness or erectile dysfunction drugs, improved sporting equipment designs, business software, cosmetics, manufactured foods packaging, or copyrighted films, music or books. The 'non-essential' requirement is imperative so as to disqualify from eligibility pre-existing IP on life-saving medical devices or treatments, vaccines, transport safety equipment, etc. essential to a healthy and active life.

The devil will lie in the details of the quid pro quo enshrined in the BPE determination process. The United States Patent and Trademark Office (USPTO), perhaps in collaboration with the National Academies of Sciences, Engineering and Medicine, would need to clearly codify criteria that would define benevolent discoveries and non-essential IP, and maintain a public listing of essential IP in force that is ineligible for extension. It might empower an expert panel that regularly meets to consider BPE applications, much as other regulatory approval agency panels rule on applications to release new pharmaceuticals or foods. USPTO would also need to develop standardized, transparent, and auditable data requirements for the determination of an appropriate duration for both the BPE and the 'assurance of availability' condition. Presumably that would rely on both rigorous benefit-cost estimates for the benevolent discovery and valuation of the non-essential IP proposed for extension, perhaps through public auction mechanisms (Kremer 1998).

A transferrable BPE would imply that the public use condition applies to the original IP applicant and any subsequent holder of that IP in the event of transfer. The "assurance of availability" condition would be inseparable from the BPE and therefore would apply to whoever holds, or more recently held, the BPE. The BPE holder could contract with a third party (e.g., a licensee of the benevolent discovery IP) to satisfy that obligation. The separability of the

quid and the quo create the real power of the BPE idea. Holders of patents nearing expiration would seek out researchers working on benevolent discoveries, who would themselves seek investors who might finance their R&D expenditures.

The idea is to target IP-protected, non-essential products and services for which the income elasticity of demand is high and the price elasticity of demand low, i.e., products demanded mainly by high socioeconomic status purchasers able and willing to pay the premium for a good or service subject to the legal monopoly conferred by a patent or copyright. By converting the foregone consumer surplus to well-off consumers of non-essential products into profit for the inventors of benevolent discoveries, BPEs can induce R&D investment and thereby generate considerable consumer and producer surplus for poor populations in LMICs and for individuals in HICs unlucky enough to suffer from rare genetic disorders.

BPEs therefore represent an explicitly redistributive mechanism to induce R&D investment. Insofar as some wealth and income inequality in the world has unjust origins (e.g., colonial conquest, illegal activities, slavery), BPEs would provide a fully voluntary, market-mediated mechanism to boost R&D to address the pressing needs of the world's poor. Importantly, no inventor would be obliged to surrender its IP and no consumer would be obliged to purchase goods or services that receive extended IP protection. Profit-minded inventors and investors would only voluntarily request a BPE to extend the life of highly profitable existing patents for non-essential products or processes. Purchasers of non-essential goods and services would still enjoy consumer surplus from voluntary purchase, they just would enjoy somewhat less consumer surplus during the period of extended patent protection. Prospective entrants into the market who would produce the non-essential item once its patent expires might lose some producer surplus from delayed legal market entry. But a vast range of alternative market entry points exist where new entrants can pursue cost-based competition around products coming off IP protection. So that loss seems negligible.

Furthermore, BPEs would not require philanthropic donations or fiscal expenditures on aid. So BPEs would not aggravate tradeoffs between, for example, longer-term R&D investments and near-term humanitarian donations, the way APCs or prizes do. BPEs would be wholly private investments.

US law – and IP law in other HICs – already allows for patent extensions beyond the usual statutory term, for example in the case of extraordinary government agency delays in processing the patent filing. The BPE would be a straightforward extension of existing patent law, granting the USPTO the authority to extend the life of existing non-essential patents, copyrights or trademarks by up to a maximum number of years (say, 20, effectively restarting the patent's life) if and only if the holder of the extended, non-essential patent likewise earns IP rights in a benevolent discovery, for example a NTD vaccine, a treatment for a rare genetic disorder that is clinically proven effective, or an improved cultivar for an orphan crop. USPTO could only grant a BPE to (i) inventors who explicitly request a BPE for (ii) a discovery that satisfies the 'benevolent discovery' criterion and that they the BPE could only apply to (iii) a 'non-essential' existing patent. An applicant filing with USPTO for a BPE would attest that in the event of the award of a BPE, the inventor will either dedicate to the public the remaining life of

the patent for the benevolent discovery or it will not enforce its remaining patent right in the discovery, with breach of that attestation resulting in forfeiture of both the new patent and that on which an extension was requested, releasing both discoveries into the public domain.

Who might invest in benevolent patents? The most obvious candidates are cash-rich firms with valuable intellectual property set to expire in the coming several years. The S&P 500 firms alone sat on $2.7 trillion in cash and liquid investments at the start of the year, even while returning near-record amounts of cash to shareholders through dividends and stock buybacks (Krantz 2022; Shoemake 2022). Firms hold cash exceeding their immediate liquidity needs when they lack high-return investment options.

Note that BPEs would not be restricted to firms with R&D expertise directly relevant to tropical crops and diseases. For example, a software developer or digital devices manufacturer could invest through a non-profit organization such as the CGIAR – the non-profit, global network of agricultural research centers – in a new variety of drought-resistant pigeon pea or teff under a contractual agreement that would require the inventor to pursue a BPE when seeking IP on the discovery and then, conditional on receiving the BPE, to transfer it to the investor. Such arrangements could unlock tens of billions of dollars in corporate cash on hand for investment in benevolent discoveries.

An important secondary effect of BPEs would be induced investment in R&D capacity – laboratories, scientific staff, etc. – in LMICs more broadly. A considerable amount of R&D in NTDs, OCs, etc. requires *in situ* exploration and experimentation working directly with affected human populations or under suitable agroecological or epidemiological conditions. Investors looking to extend a lucrative patent or copyright on a non-essential discovery would likely find it advantageous to invest in R&D in the places where benevolent discoveries are needed. Such investments in scientific capacity in LMICs would generate considerable spillover benefits for agricultural productivity and broader economic growth and in disease and poverty reduction.

**Conclusions**

The COVID-19 experience has demonstrated both the world's incredible ability to mobilize funding and scientific expertise to develop impactful discoveries as well as the inequitable distribution of those gains because of pre-existing differences in commercial market size. A relatively simple extension to existing IP law could harness the latent power of the private sector to similarly mobilize considerable private R&D investment to address the agricultural, biomedical and other essential needs of the world's poor. Currently, the owners of soon-to-expire patents invest massively in minor improvements that might permit them to replace those patents and in planned obsolescence. BPEs would reduce incentives for planned obsolescence and offer an alternative, more socially beneficial use for those investments.

BPEs could be combined with any of the pre-existing tools that already exist to help induce such R&D investments. The objective is to supplement, not replace, instruments similarly intended to induce much-needed investment in R&D to address major societal challenges for which negligible commercial market exists. The more tools available, the better.

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Supplementary Materials to

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The estimates presented here are necessarily coarse, drawing together estimates found in the most reputable and recent sources we could find. These materials detail the sources and methods behind these estimates. The companion spreadsheet includes links to all sources and shows for each disease or crop a low and high estimate of the number of affected persons.

The aggregate estimates of those affected by neglected tropical diseases (NTDs), rare diseases, or orphan crops – as detailed below – are:

| Total Affected Population from (i)-(iii) Categories (Low Estimate) | Total Affected Population from (i)-(iii) Categories (High Estimate) |
|---|---|
| **3,203,570,973** | **4,531,610,973** |

## Neglected Tropical Diseases (NTDs)

### Selected NTDs

Diseases were selected from the World Health Organization's (WHO) portfolio of NTDs, as listed on the Centers of Disease Control and Prevention's (CDC) (https://www.cdc.gov/globalhealth/ntd/diseases/index.html)

### Affected Individuals

Data were collected from CDC, WHO, and the Food and Agriculture Organization (FAO). "High estimate" and "low estimate" figures were introduced when numbers did not align between the three sources. "Data Source" ('BPE Table' Column E) lists such occurrences in the order of Low Estimate Citation; High Estimate Citation.

| | Affected Individuals (Low Estimate) | Affected Individuals (High Estimate) | Data Source | Notes |
|---|---|---|---|---|
| Neglected Tropical Diseases | *2,419,846,911* | *3,564,886,911* | https://www.cdc.gov/globalhealth/ntd/diseases/index.html | *Italicized* NTDs can be "controlled or even eliminated through mass administration of safe and effective medicines or other, effective interventions," according to the CDC. |
| Buruli Ulcer | 1,258 | 1,258 | https://www.who.int/news-room/fact-sheets/detail/buruli-ulcer-(mycobacterium-ulcerans-infection) | |
| Chagas Disease | 6,000,000 | 7,000,000 | https://www.who.int/news-room/fact-sheets/detail/chagas-disease-(american-trypanosomiasis) | |
| Cysticerocosis | 2,560,000 | 8,300,000 | https://www.who.int/news-room/fact-sheets/detail/taeniasis-cysticercosis | |
| Dengue Fever | 100,000,000 | 400,000,000 | https://www.who.int/news-room/fact-sheets/detail/dengue-and-severe-dengue | |
| *Dracunculiasis (Guinea Worm Disease)* | 54 | 54 | https://www.who.int/news-room/fact-sheets/detail/dracunculiasis-(guinea-worm-disease) | |
| Echinococcosis | 1,000,000 | 1,000,000 | https://www.who.int/news-room/fact-sheets/detail/echinococcosis | |
| Fascioliasis | 2,400,000 | 2,400,000 | http://www.fao.org/3/cb1127en/cb1127en.pdf | |
| Human African Trypanosomiasis (African | 992 | 992 | https://www.who.int/en/news-room/fact-sheets/detail/trypanosomiasis-human-african-(sleeping-sickness) | |
| Leishmaniasis | 700,000 | 1,000,000 | https://www.who.int/news-room/fact-sheets/detail/leishmaniasis | |
| Leprosy | 208,000 | 208,000 | https://www.cdc.gov/parasites/lymphaticfilariasis/gen_info/faqs.html | |
| *Lymphatic Filariasis* | 51,000,000 | 120,000,000 | https://www.cdc.gov/parasites/lymphaticfilariasis/gen_info/faqs.html; https://www.who.int/news-room/fact- | |
| Mycetoma | 17,607 | 17,607 | https://www.cdc.gov/fungal/diseases/mycetoma/index.html | |
| *Onchocerciasis* | 20,900,000 | 20,900,000 | https://www.who.int/news-room/fact-sheets/detail/onchocerciasis | |
| Rabies | 59,000 | 59,000 | https://www.cdc.gov/rabies/location/world/index.html | |
| *Schistosomiasis* | 240,000,000 | 240,000,000 | https://www.who.int/news-room/fact-sheets/detail/schistosomiasis | |
| *Soil-transmitted Helminths (STH) (Ascaris* | 807,000,000 | 1,221,000,000 | https://www.cdc.gov/parasites/sth/index.html | |
| *Soil-transmitted Helminths (STH) (Hookw* | 576,000,000 | 740,000,000 | https://www.cdc.gov/parasites/sth/index.html | |
| *Soil-transmitted Helminths (STH) (Whipw* | 604,000,000 | 795,000,000 | https://www.cdc.gov/parasites/sth/index.html | |
| *Trachoma* | 8,000,000 | 8,000,000 | https://www.cdc.gov/healthywater/hygiene/disease/trachoma.html | |

## Rare Diseases

Because there are more than 7,000 different rare genetic disorders, only those that have been validated, have worldwide prevalence data (rather than only region-specific prevalence estimates), and occur more than one in one million have been listed. Under these criteria, we list 200 identified on Orphanet (http://www.orphadata.org/cgi-bin/epidemio.html). Orphanet does not estimate the total affected individuals of these 200 rare genetic disorders; it instead estimates a range of worldwide prevalence. Our "Estimated Worldwide Cases (Low)" and "Estimated Worldwide Cases (High)" are calculated by multiplying the respective prevalence by the world population.

This method omits approximately 6,800 other rare diseases. To account for the worldwide population of other rare genetic disorders, we used the total population range estimates for rare genetic disorders from Wakap et al. (2020), from which we subtracted those estimated to suffer from the 200 rare genetic disorders we account for directly.

| | Affected Individuals (Lower Estimate) | Affected Individuals (High Estimate) | Data Source |
|---|---|---|---|
| Rare Disease | 263,000,000 | 446,000,000 | https://doi.org/10.1038/s41431-019-0508-0 |
| Canavan disease | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Cystinosis | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Glycogen storage disease due to glycoge | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Krabbe disease | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Beta-thalassemia | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Steinert myotonic dystrophy | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Thomsen and Becker disease | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Angelman syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Marfan syndrome | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Huntington disease | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Huntington disease | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Down syndrome | 4,728,000 | 7,092,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Oculocerebrorenal syndrome of Lowe | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Retinoblastoma | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Fragile X syndrome | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Mucopolysaccharidosis type 2 | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Mucopolysaccharidosis type 1 | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Wilson disease | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Wilson disease | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| X-linked retinoschisis | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Williams syndrome | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Achondroplasia | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Ornithine transcarbamylase deficiency | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Classic homocystinuria | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Leber hereditary optic neuropathy | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Neurofibromatosis type 1 | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Chronic granulomatous disease | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Blue cone monochromatism | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Blue cone monochromatism | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Gorlin syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Cystinuria | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Peutz-Jeghers syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| WAGR syndrome | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Albers-Schönberg osteopetrosis | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Coffin-Lowry syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Meckel syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Ellis Van Creveld syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Partial chromosome Y deletion | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Idiopathic achalasia | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Idiopathic achalasia | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Monosomy 18q | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Acromegaly | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Smith-Magenis syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Cleidocranial dysplasia | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Distal arthrogryposis type 1 | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Congenital diaphragmatic hernia | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Hartnup disease | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Pycnodysostosis | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Classical Ehlers-Danlos syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Fanconi anemia | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Sporadic Creutzfeldt-Jakob disease | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Osteogenesis imperfecta | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Glycogen storage disease due to glucose | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Gaucher disease | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Hirschsprung disease | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Myasthenia gravis | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |

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|---|---|---|---|
| Maple syrup urine disease | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Congenital lobar emphysema | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Wolfram syndrome | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Cleft lip/palate | 4,728,000 | 7,092,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Sarcosinemia | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Primary sclerosing cholangitis | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Primary sclerosing cholangitis | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Tay-Sachs disease | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Infantile spasms syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Primary biliary cholangitis | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Primary biliary cholangitis | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Budd-Chiari syndrome | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Budd-Chiari syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Listeriosis | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Progressive supranuclear palsy | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Progressive supranuclear palsy | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Differentiated thyroid carcinoma | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Joubert syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Trisomy 12p | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Leishmaniasis | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Leprosy | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Legius syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Colonic atresia | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Serrated polyposis syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Pentalogy of Cantrell | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Dysplasia epiphysealis hemimelica | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| 46,XX ovotesticular disorder of sex devel | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| 8p23.1 duplication syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Buschke-Ollendorff syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Papillon-Lefèvre syndrome | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| 16p13.11 microdeletion syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Mayer-Rokitansky-Küster-Hauser syndro | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Pseudoachondroplasia | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Uhl anomaly | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Truncus arteriosus | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Weill-Marchesani syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Nijmegen breakage syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Thalidomide embryopathy | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Dysbetalipoproteinemia | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Herpes simplex virus encephalitis | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Leber congenital amaurosis | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Leber congenital amaurosis | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Aplasia cutis congenita | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Propionic acidemia | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Glutaryl-CoA dehydrogenase deficiency | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Medium chain acyl-CoA dehydrogenase | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Univentricular heart | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Autoimmune pulmonary alveolar proteii | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Congenitally corrected transposition of t | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Tyrosinemia type 1 | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Von Willebrand disease | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Birdshot chorioretinopathy | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Optic pathway glioma | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Double outlet left ventricle | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Pulmonary arteriovenous malformation | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Anisakiasis | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Lymphangioleiomyomatosis | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Severe hereditary thrombophilia due to | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |

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|---|---|---|---|
| Malignant peripheral nerve sheath tumc | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Isolated agammaglobulinemia | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Zollinger-Ellison syndrome | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Hyperphenylalaninemia due to tetrahyd | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Chronic nonbacterial osteomyelitis/Chrc | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Chronic nonbacterial osteomyelitis/Chrc | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Oculocutaneous albinism type 1 | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Congenital absence of upper arm and fo | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Mitochondrial membrane protein-associ | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Shwachman-Diamond syndrome | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Shwachman-Diamond syndrome | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Acute generalized exanthematous pustu | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| 46,XX testicular disorder of sex developm | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Primary Sjögren syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Isolated tracheoesophageal fistula | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Ectopia cordis | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Necrotizing enterocolitis | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Homozygous familial hypercholesteroler | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Placental insufficiency | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Hereditary pheochromocytoma-paragan | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Multiple myeloma | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Isolated biliary atresia | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Multiple system atrophy | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Multiple system atrophy | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Pseudomyxoma peritonei | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Multifocal motor neuropathy | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| GNE myopathy | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Squamous cell carcinoma of the nasal ca | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Squamous cell carcinoma of the lip | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Relapsing polychondritis | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Multifocal atrial tachycardia | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Antisynthetase syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Peripartum cardiomyopathy | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Cholangiocarcinoma | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Cholangiocarcinoma | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Congenital heart block | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Enlarged parietal foramina | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Craniopharyngioma | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Adamantinoma | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Eosinophilic esophagitis | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Isolated plagiocephaly | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Bacterial toxic-shock syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Buerger disease | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Dravet syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Retinitis punctata albescens | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Muenke syndrome | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Caroli disease | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Thrombotic thrombocytopenic purpura | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Achromatopsia | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Lambert-Eaton myasthenic syndrome | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Gastrointestinal stromal tumor | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |

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|---|---|---|---|
| Pyoderma gangrenosum | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Mal de Meleda | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Crouzon syndrome-acanthosis nigricans | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Jervell and Lange-Nielsen syndrome | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Classic congenital adrenal hyperplasia d | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Non-functioning pituitary adenoma | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Severe generalized junctional epidermol | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Oculocutaneous albinism type 4 | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Oculocutaneous albinism type 2 | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Hermansky-Pudlak syndrome | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Nodular lymphocyte predominant Hodg | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Insulinoma | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| X-linked adrenal hypoplasia congenita | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Familial thyroid dyshormonogenesis | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Thyroid hemiagenesis | 788,000 | 3,940,000 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Thyroid hypoplasia | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Juvenile dermatomyositis | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Congenital total pulmonary venous retu | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Paroxysmal non-kinesigenic dyskinesia | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Paroxysmal kinesigenic dyskinesia | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Hemophilia B | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Duchenne muscular dystrophy | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Autosomal dominant optic atrophy, clas | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Spinocerebellar ataxia type 1 | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Spinocerebellar ataxia type 2 | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Spinocerebellar ataxia type 3 | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Galactose mutarotase deficiency | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Primary hepatic neuroendocrine carcino | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Squamous cell carcinoma of the esophag | 78,800 | 709,200 | http://www.orphadata.org/cgi-bin/epidemio.html |
| Adenocarcinoma of the esophagus | 7,880 | 70,920 | http://www.orphadata.org/cgi-bin/epidemio.html |
| *Other Rare Genetic Disorders* | 224,388,000 | 251,364,000 | http://www.orphadata.org/cgi-bin/epidemio.html |

## Orphan Crops

### Selected Orphan Crops

The primary source is the compilation from AfricanOrphanCrops.org (http://africanorphancrops.org/meet-the-crops/). We supplemented that listing with others that referenced a crop as a “neglected", "orphan" or "underutilized" crop, generating a total of 49 specific orphan crops.

### Affected Individuals

No publication clearly delineates population of orphan crop farmers broken down by crop. Therefore, we had to make coarse estimates as follows, using FAO Stat data unless indicated otherwise. In 2019, FAO reports approximately 1,567,681,000 hectares of cropland in cultivation and an estimated population of 2,053,332,180 farmers. This yields a farmer/hectare ratio of 1.31 globally. We then multiply that mean ratio by FAO's reported area cultivated in each of the 49 orphan crops. That is our low estimate. We also consider the 137,558,294 hectares of cultivated acreage not directly assigned to a crop by FAOStat, assuming that all unaccounted acreage reflects orphan crops, and labeling that "Other orphan crops" to create a high end estimate.

| | Affected Individuals | Data Source | Notes |
|---|---|---|---|
| Orphan Crops | *520,724,062* | http://africanorphancrops.org/meet-the-crops/ | |
| Okra | 3,575,478 | http://www.fao.org/faostat/en/#data/QC | |
| Onions, dry | 6,801,280 | http://www.fao.org/faostat/en/#data/QC | |
| Onions, shallots, green | 288,476 | http://www.fao.org/faostat/en/#data/QC | |
| Cashew | 9,288,078 | http://www.fao.org/faostat/en/#data/QC | |
| Papayas | 605,846 | http://www.fao.org/faostat/en/#data/QC | |
| Watermelons | 4,039,675 | http://www.fao.org/faostat/en/#data/QC | |
| Coconuts | 15,464,889 | http://www.fao.org/faostat/en/#data/QC | |
| Taro | 2,563,727 | http://www.fao.org/faostat/en/#data/QC | |
| Jute | 1,883,397 | http://www.fao.org/faostat/en/#data/QC | |
| Pumpkins, squash, and gourds | 2,015,796 | http://www.fao.org/faostat/en/#data/QC | |
| Fonio | 1,199,991 | http://www.fao.org/faostat/en/#data/QC | |
| Yams | 11,670,860 | http://www.fao.org/faostat/en/#data/QC | |
| Millet (Finger Millet) | 41,459,918 | http://www.fao.org/faostat/en/#data/QC | Orphan Crops (also referred to as neglected crops, underutilized crops, and underused crops) were primarily retreived from African Orphan Crops Consortium, but also from a number of peer-reviewed journals and other academic publications. Find sources of crop classification within the sheet 'Orphan Crops Calculation' under "Orphan Status." Refer to 'Orphan Crops Calculation' for how affected individuals were estimated. There are over 20,000 species of edible plants so an "other" category must be added. Refer to 'Orphan Crops Calculation' for reasoning on "Other Orphan Crops" calculation (bottom). |
| Mangoes, mangosteens, guavas | 7,320,042 | http://www.fao.org/faostat/en/#data/QC | |
| Sweet potato | 10,175,585 | http://www.fao.org/faostat/en/#data/QC | |
| Lentils | 6,287,012 | http://www.fao.org/faostat/en/#data/QC | |
| Groundnut | 38,765,800 | http://www.fao.org/faostat/en/#data/QC | |
| Avocados | 951,772 | http://www.fao.org/faostat/en/#data/QC | |
| Green bean | 2,160,774 | http://www.fao.org/faostat/en/#data/QC | |
| Bambara groundnut | 485,870 | http://www.fao.org/faostat/en/#data/QC | |
| Shea | 1,100,835 | http://www.fao.org/faostat/en/#data/QC | |
| Cocoyam (Yautia) | 52,515 | http://www.fao.org/faostat/en/#data/QC | |
| Cassava | 36,045,465 | http://www.fao.org/faostat/en/#data/QC | |
| Pigeon pea | 7,355,978 | http://www.fao.org/faostat/en/#data/QC | |
| Triticale | 4,987,235 | http://www.fao.org/faostat/en/#data/QC | |
| Quinoa | 241,768 | http://www.fao.org/faostat/en/#data/QC | |
| Agave | 84,298 | http://www.fao.org/faostat/en/#data/QC | |
| Coriander | 2,719,921 | http://www.fao.org/faostat/en/#data/QC | |
| Asparagus | 2,126,759 | http://www.fao.org/faostat/en/#data/QC | |
| Favabean (broad beans) | 3,375,591 | http://www.fao.org/faostat/en/#data/QC | |
| Buckwheat | 2,191,904 | http://www.fao.org/faostat/en/#data/QC | |
| Carobs | 18,816 | http://www.fao.org/faostat/en/#data/QC | |
| Castor Oil Seed | 1,517,534 | http://www.fao.org/faostat/en/#data/QC | |
| Cowpea | 18,922,970 | http://www.fao.org/faostat/en/#data/QC | |
| Gooseberry | 19,572 | http://www.fao.org/faostat/en/#data/QC | |
| Chicory | 1,723,720 | http://www.fao.org/faostat/en/#data/QC | |
| Lupins | 1,161,929 | http://www.fao.org/faostat/en/#data/QC | |
| Mate | 346,700 | http://www.fao.org/faostat/en/#data/QC | |
| Persimmons | 1,299,868 | http://www.fao.org/faostat/en/#data/QC | |
| Pistachios | 1,355,365 | http://www.fao.org/faostat/en/#data/QC | |
| Plantains | 7,485,078 | http://www.fao.org/faostat/en/#data/QC | |
| Pulses | 7,854,144 | http://www.fao.org/faostat/en/#data/QC | |
| Quinces | 122,726 | http://www.fao.org/faostat/en/#data/QC | |
| Safflower seed | 855,004 | http://www.fao.org/faostat/en/#data/QC | |
| Sesame Seed | 16,793,797 | http://www.fao.org/faostat/en/#data/QC | |
| Sorghum | 52,489,380 | http://www.fao.org/faostat/en/#data/QC | |
| String beans | 191,803 | http://www.fao.org/faostat/en/#data/QC | |
| Tallow tree | 561,111 | http://www.fao.org/faostat/en/#data/QC | |
| Vetches | 545,595 | http://www.fao.org/faostat/en/#data/QC | |
| *Other Orphan Crops* | 180,172,415 | | |