Title: A Global View of Pediatric Urology

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Summary

Over the course of approximately 60 years, the field of pediatric urology has evolved as a convergence of pediatric surgery, urology plastic surgery to address congenital anomalies of the urinary tract and genitalia in children. Guidelines for training and certification are narrowing in high-income countries (HICs) as the fertility rate is declining and the prevalence of complex genitourinary (GU) conditions is decreasing. In low-and middle-income countries (LMICs) large populations with few surgeons and underfunded systems to support surgical care are currently in a state of stress. Here we briefly review the history of pediatric urology as a surgical subspecialty, identify unmet needs especially in LMICs and place the field in the context of an emerging concept of a global surgical ecosystem.

Methods: The English language literature on the workforce trends in pediatric urology, pediatric surgery and urology was reviewed as well as development of the emerging field of global surgery. Global surgery looks at the social, economic and political context of health systems as well as unmet clinical need. World trends in fertility rates were reviewed to identify regions of workforce surplus and gaps, supply chain needs, infrastructure and systems strengths and weaknesses.

Results: The proliferation of training programs in pediatric surgery and specialties in high income countries (HICs) coupled with declining birth rates has led to a saturation and declining surgical case load. In LMICs countries, while the birth rate has also been declining, surgical
specialization has not progressed, and the lowest income countries, especially in sub-Saharan Africa, training in pediatric surgical specialties and urology is rare, despite increasing populations of children. The broad workforce that supports surgical care, such as anesthesia, intensivist pediatrics, radiology, laboratory, and nursing face similar challenges. Supply chains for specialized pediatric urological surgery are weak.

Conclusion: There is an evolving maldistribution of pediatric surgical and pediatric urological workforce globally, with too few practitioners in LMICs and too many in HICs. The high cost of specialized equipment limits access to quality care, and the supply chain for consumables and medication are patchy. In LIC’s basic community-based infrastructure for health including reliable electricity is lacking. Recent experience with Covid and environmental disasters has highlighted that even in HICs surgical resilience can be challenged. This is an opportunity to consider the state of children’s urological care globally and to build resilience by identifying and addressing strengths and gaps.

Key Words: Pediatric urology, Workforce, Global surgery, Surgical ecosystem

Introduction

Pediatric urology is a young specialty. Barely a working generation into existence, it is challenged by a frustrating complexity of health systems globally and widening gaps in resources. As surgeons and as patients, our opportunities for both providing and receiving care vary greatly around the world. In low-income countries, surgeons face poor access to training, to
hospitals with good equipment and to staffing. Patients face the potential for catastrophic direct financial burden as well as indirect costs of travel and long-term care of family members. In some global regions, there is an over-abundance of surgeons relative to the pediatric population, and in others, a scarcity. In a few regions the pediatric population is growing, but in many others, declining. As the field of “global surgery” has become a bona fide academic discipline, new avenues are opening for identifying systems-related challenges in providing quality pediatric urological care. We can now begin to identify points of potential change to improve both quality and access to children’s surgical care around the world.

A framework for inquiry into the current state and future needs for global surgery in general and pediatric urology in particular considers surgery as an ecosystem within larger healthcare systems worldwide (1,2,3). Optimal resources for children’s surgical care can be considered within this framework (4). Pediatric urology, as the convergence of urology and pediatric surgery, interfaces with a broad spectrum of generalists and specialists within the surgical, medical and diagnostic disciplines as well as the frontline health workforce and public health. To get larger view of the current challenges and opportunities for pediatric urology we must look at the global burden of disease, the workforce, the hospitals, the community, infrastructure and all the consumables necessary for quality care. Systems are continually in flux, but awareness of the component factors will provide opportunity for positive change.

**Burden of Disease**

Pediatric surgery and its subspecialties have evolved organically in high income countries (HICs), but in low-and middle-income countries (LMICs) there is now a collaborative attempt to
strategically plan for human and infrastructure resources and to embrace public health methods to identify and meet the burden of disease. The evolution of pediatric urology in HICs has been from open surgery to minimally invasive, and from surgical to medical and functional therapies. The scope of care has also broadened at both ends of childhood to include fetal urology and adolescent and adult transitional care. The burden of urological conditions is shifting from acute to chronic disease. In LICs, the situation is very different. Although databases and registries of congenital anomalies are lacking, late-stage presentation and backlogs of congenital surgical conditions can be staggering. Ninety percent of the burden of pediatric surgical disease occurs in LMICs (5). Genitourinary conditions represent the third most common types of non-chromosomal congenital anomalies, after heart and limb defects, in Europe and it may be assumed that the same holds true in LMICs (6,7). This burden can be considered as “avertable” or “non-avertable” (8,9,10). In pediatric urology, many neural tube defects could be considered avertable depending on the availability of dietary folic acid supplements; hypospadias may be partially avertable depending on maternal environmental exposures, and bladder exstrophy might be considered non-avertable. Late presentation and lack of radiology limits triage and therapy for solid tumors as well as luminal obstructions such as ureteropelvic junction, ureterovesical junction and posterior urethral valves where prenatal ultrasound is not routinely performed. Acquired problems that were once common in HICs like bladder stones are now rare even in MICs but still seen in many LICs with otherwise high stone rates (11,12).

The most common pediatric urological conditions both in HICs and in LMICs are undescended testis, hydrocele and hypospadias. It is useful to compare hypospadias to clefts because they are both visible and well-studied. The global backlog is estimated to be 2.1 million cleft surgeries
(13,14). Hypospadias prevalence is believed to be >5 times greater than cleft, but prevalence trends indicate significant variability and large gaps in data. (6,15). The backlog for surgery, even if it is available, can be staggering, with wait times for orchidopexy in excess of 70 months in Kenya (16). A 2018 estimate of surgical backlog in African LICs revealed the most pronounced backlog of pediatric urological cases was for cryptorchidism in Nigeria and for hypospadias in Ethiopia (17). In LMICs globally, backlogs are common for all types of urological conditions (18).

Among the complex multisystem conditions with a major urological component, spina bifida is the most prevalent and the most avertable through supplementation of foods with folic acid. Mandatory folic acid fortification has been implemented in many LICs (including in East, Central and Southern Africa), but not in many HICs including most of Europe. Over 250,000 cases could be preventable with universal fortification globally (19) (Fig 1). Bladder extrophy-epispadias complex, though significantly rarer, represents an unmet need because of its multisystem complexity, the requirement for specialized surgical teams and the life-long social and economic challenges faced by patients and their families. Given prevalence and current birth rates, the burden of congenital urological disease now and in the foreseeable future will be carried by countries least able to manage it.

**Global evolution of pediatric urology:**

Through the colonial era and emerging from it, urological care in poor countries was carried out by general surgeons or doctors without specific surgical training (20). But training is changing globally. New doctors learn not just through apprenticeship but through multimedia and
professional and social networks. It is increasingly recognized that sustainable surgery requires the engagement of many different stakeholders including many outside of medicine. Some are in ministries of health or finance, patient advocate groups and multispecialty collaborative alliances. They are engaging the tools of public health and economics to make the case for investment in surgical care as an indivisible component of health (21,22). The ecosystems that support surgery, as we have seen with the Covid pandemic, also support the entire system of health.

Five major forces have converged to reshape priorities and strategies for surgery globally. The study of these forces has led to the development of a new field within surgery, especially academic surgery, known as “Global Surgery” (23): 1. The epidemiologic transition of diseases from primarily infectious to more chronic conditions. In pediatric urology there is a transition from primarily surgical care to behavioral and medical care; 2. Widespread mobility of the world’s populations, including both patients and practitioners; 3. Rapidly increasing information access enabling widespread participation from both the surgical community and patient communities; 4. A revolution for equity and human rights where health disparities between LMICs and HICs are no longer acceptable; 5. Recognition of the cost-effectiveness and value of surgical care, including pediatric surgical care and its potential to build economies. Children’s surgery’s long-term benefits are particularly notable when compared to the costs of disability and the indirect costs of delayed or neglected care (16,24, 25). In this light, pediatric urological care in LMICs can now be seen as an investment rather than merely a cost.
The last decade has seen a sea change in collaboration among the healthcare communities that actively participate in surgery, including surgeons and surgical societies, anesthesia, obstetrics and gynecology, and pre and in-hospital trauma care. These also include nonprofit surgical organizations (aka non-government groups or NGOs), academics, student and trainee communities and patient communities. From the perspective of pediatric urology these currently include pediatric surgical organizations such as the World Federation of Associations of Pediatric Surgery (WOFAPS) (26), the Global Initiative for Children’s Surgery (GICS) (27), urological organizations- Societies for Pediatric Urology (SPU) (28) and other regional pediatric urological societies and groups. Two major influential publications in 2015 also grounded the move toward global investments in surgical care. The Lancet Commission’s “Global Surgery 2030: Evidence and solutions for achieving health, welfare, and economic development” and the World Bank’s Disease Control Priorities 3, Volume 1, “Surgery” tied together many threads of prior work and set the stage for new research on surgical care in the global setting (21,29).

Academic programs in global surgery are springing up in HICs and most of these have active collaborations in LMICs. Funding is becoming more available through government research grant and aid mechanisms, professional societies, and private foundations--although not nearly at the same level as disease-specific funding. The recently formed Global Surgery Foundation, formed under the auspices of the United Nations Institute for Training and Research (UNITAR) partners with many of the leading organizations in global surgery (30). As more awareness of the surgical ecosystem enters the curriculum of medical school or surgical residencies, students and trainees are driving much of the transformation through groups such as the Global Surgery Student Association (GSSA) (31) and InciSion (32). The Association of Academic Global
Surgery (33) and member organizations and individuals have been active participants in helping LMICs develop their National Surgical, Obstetrics, and Anesthesia Plans (NSOAPs) which have been blueprints for supporting surgical care at the national level (34). When looking at unmet needs in surgical care, Paul Farmer has popularized the mnemonic of the ‘Four (or five) S’s”—Staff, Stuff, Space and Systems (36) and now the fifth, Social Support (37).

**Workforce (Staff)**

Planning for current and future workforce needs involves knowing 1) the size of the current workforce, 2) the number of years to produce specialists, 3) the prevalence of disease and the current backlog of cases, and 4) the financing structures to cover cost of scale-up for health systems and patients. Traditional training pathways may not serve the current need in HICs or in LMICs due to time constraints and financing. Historically general surgeons have always cared for children with tumors, trauma and congenital anomalies. Pediatric surgery and its specialties evolved coincident with the evolution of pediatrics, specialized anesthesia, antibiotics, and hospitals dedicated to children’s care (38). Adult urology branched away from general surgery somewhat earlier with the technological advent of cystoscopes and resectoscopes for the lower urinary tract and their attendant consumables—catheters and stents. The first pediatric cystoscope was reported by Beer in 1911, but initially its use did not spread widely. It was not until after World War II that clinical exchanges and formal training took off (39). The early years of pediatric urology in England and America saw active collaborations between a relatively small number of adult urologists and pediatric surgeons from 1948 through the ‘60’s. Training programs in pediatric urology began to proliferate between the US and UK, and clubs and associations of Pediatric urology were formed—the Society of Pediatric Urology (SPU) in 1951,
the Section on Urology of the American Academy of Pediatrics in 1960, Society for Pediatric Urological Surgeons SPUS in 1963 and BAPU in 1992 (42). Pediatric urology grew across Europe at about the same time (41), through the 1960’s and the formation of the European Society of Pediatric Urology ESPU in 1989 (42). Dedicated training programs and societies have now developed in all major global regions except sub-Saharan Africa (18,43-46). As regional gaps are filled, many local gaps remain.

The enthusiasm for childrens’ surgery has led to a current saturation of pediatric surgeons and urological sub-specialists in HICs and some MICs. This includes Canada, the UK, the US, and many countries in Latin America and Europe (47-50). In the U.S., in the last 25 years, even as the rate of population growth has flattened and declined, (51) the numbers of fellowship programs has more than doubled and the pediatric urology specialists continue to increase (Fig 2). A 2009 review of billing logs from practicing pediatric urologists in the US supports the concern that the majority of cases that practicing pediatric urologists in the US see are now penile and groin cases (50,52). In HIC’s, the prevalence of complex cases like bladder extrophy and cloaca is sufficiently low that few pediatric urologists will see and care for enough cases to become expert, but in LMICs with higher birth rates, the numbers of cases overwhelm the few pediatric surgical specialists.

It is sobering to consider that surgeons in HICs who have dedicated from seven to 10 years or more in surgical training may predominantly operate more minor cases such as circumcisions, hernias and undescended testes after a decade of specialized educational investment. Behavioral and functional pediatric urology (office urology) as well as minor procedures occupy a
substantial percentage of clinical time. Non-MD advanced practice clinicians and nurses can help the situation, but they do not change the operative case mix for surgeons. At the same time, there is a critical unmet need for complex pediatric surgery including urology in many LMICs. In sub-Saharan Africa (SSA), where most pediatric urology is served by pediatric surgeons, the number of pediatric surgeons positively correlates with GDP per capita, and inversely with the birth rate, where fertility is the highest in the world (53, 54) (Fig 3).

Historically surgical trainees from SSA have traveled to the UK for training. The British-trained surgeons including urologists who return to their home countries have faced re-adjustment to the limitations of their home facilities, health financing and prioritization (55). Other models for international engagement involve long-term bilateral academic or volunteer exchanges. Well-designed programs help to maintain and develop skills in complex surgery in collaboration between high -and low- income regions. (6,56-58).

Benchmarks for scaling general pediatric surgery worldwide have been proposed to achieve balanced workforce density (49). Considering the population growth rates in this region, the pediatric surgeon deficit in all of Africa, including North and South Africa, was >2,500 in 2016. Other regions with large total need were in Asia (>5500) where, although the growth rate is leveling off, the baseline population and backlog of surgical cases is great. By this standard, North America, South America and the Middle East have excess pediatric surgical density (48,49). Latin American countries reported adequate or excess numbers of specialists. Compounding regional disparities is that most specialists live and practice in major cities.
The major factor limiting the pediatric surgical workforce in SSA and LMICs in general is the paucity of training centers. In India in 2016 there were ~1/9 million children; for Africa ~1/9.5 million (with more than half in just 3 countries) whereas in North America here are 1/1.5 million. The pipeline of medical students considering surgery is short, as students often balk at the length of training, lifestyle and lack of mentors (53) Medical students also lack exposure to urology during their student years (60).

Three surveys designed to identify unmet need for pediatric urology in LMICs highlighted differences in perception between specialists as well as common themes for building capacity (18). Pediatric surgeon respondents who work in LMICs or were from LMICs identified training as the highest priority. Favored training options ranked from local/regional training (most favored) to short visits from HIC volunteers, to training abroad. Training abroad ranked least favored.

In SSA, there is one formal pediatric urological fellowship training program, at Red Cross War Memorial Children’s Hospital in South Africa and four fellowship-trained pediatric urologists—one in Uganda, one in Cote d’Ivoire, and two in Ghana and another in training from Zimbabwe. But across Africa, most pediatric surgeons do manage urological conditions and more than 60% of LMIC surgeons surveyed felt either quite confident or fairly confident in their ability to manage them (18).
Quality pediatric urology requires quality anesthesia. Anesthesia is most frequently provided by nurses or general anesthesiologists except in dedicated children’s hospitals. The number of pediatric specialist anesthetists is unknown for most LMIC’s but in many countries, the number of MD anesthetists is small (17,61). The full complement of the medical workforce including diagnostics, radiology and pathology, oncology (solid tumors) adult urology (transitional care) endocrine (DSD), ObGyn, (fetal surgery), immunology/ID (infection, microbiome management), nephrology, neonatology, ICU, nurses, pharmacists, dietitians, patient advocacy groups are also critical for success and sustainability.

**Hospitals (Space).**

Surgical care takes place in hospitals, but hospitals, are facing revolutionary changes. Whereas children’s hospitals in HICs increasingly care for chronic multisystem conditions at increasing cost (62), in LMICs, children’s hospitals are still rare (63). Centralized computer systems, “Enterprise Data Warehouses” have been slow to be adopted, partly due to the cost of hardware and software, partly to IT and clinical staff training and partly due to unstable and undependable electrical grids and wireless systems and other community-based infrastructure. The Global Initiative for Children’s Surgery has identified optimal resources for children’s surgery at each level of hospital care using the DCP3 classification (4). Investment in dedicated children’s facilities has measurable yield in economic terms- in dollars and in disability averted. One children’s OR created a net economic benefit of over $5 million USD in the first year of operation for a hospital in Uganda and 6447 disability-adjusted life years were averted (64).
As pediatric urology has become a highly technical field in HIC settings, robotic surgery preferentially taught over open surgical techniques (65). Fetal and transplant surgery enable survival of babies and children with previously lethal conditions but commit them to require hospitals equipped with expert neonatal and pediatric services, radiology, lab services, and pediatric specialists, nutritional specialists and appropriate pharmaceutical supplies. In HICs there is at least one potential loss, that is the skill set of open surgery that permits fruitful technical exchange between HICs and LMICs.

For the large populations of children in LICs, the presence of even one functional infant cystoscope or resectoscope capable of resecting PUVs is rare. Sterile, bagged water is not available. Non-latex foley catheters and often pediatric sized catheters are not to be found. As mentioned in the previous section, hospitals in LICs still struggle with inconsistently available electricity (Fig 4), poor supply chain, inefficient waste management, poorly equipped ORs, and even more poorly equipped recovery rooms. NGOs have attempted to mitigate these problems with donations of surplus equipment, but it is often unusable because due to mismatch of locally available power sources, cleaning methods or training. Service contracts with vendors usually do not apply to used donated equipment where even screw-threads and plugs are not always standardized or interchangeable. To address this need, some NGOs such as KidsOR (63) and Build Health International (66) as well as faith-based, and private local and international hospitals are building dedicated pediatric ORs and hospitals.

Stuff:
Whereas in HICs products often drive medical and surgical care, in LMICs, instruments and consumable products are lacking. Consider the number of line items necessary for an operative day in pediatric urology: for anesthesia to provide airway management for neonates to adult-size children; for the surgeon, a complement of sutures, staples, wires, catheters, stents, etc. Pieces of major equipment are often necessary, including monitors, towers, diathermy, light sources and in some cases laser or fluoroscopy. In HIC’s, the process for ordering, sterilizing, maintaining and disposing of surgical “stuff” is routine. Most surgeons from HICs are not aware of the quantity or life-cycle of the materials that they use until they travel to a place where it is not available. Similarly, availability of the wide variety of medications including anticholinergics specific to urology is dependent on pharmacies, which are often not on-site, or hospital formularies determined by government agencies. In some LICs, patients and families are expected to purchase all materials and medications at off-site dispensaries prior to surgery, risking inadvertently purchasing poor quality suture or counterfeit medication. Surgical wards rarely stock pulse oximeters or suction, and parents are often responsible for the care and feeding of post-operative children.

**System:**

Surgery can be considered either as a cost or as an investment for individuals, families, communities or countries. It has the potential to restore function and economic productivity but also to cast many into poverty. Most HICs and MICs have provisions for children’s healthcare through mixes of government and private health guarantees but in LICs they remain inadequate (67). In most of SSA where health remains within the cash economy, the risk of catastrophic impoverishment of families due to direct and indirect costs of surgical conditions affects 49% of
the population of LIC’s, but even small investments can yield large benefits (26). An increasing
body of work has been quantifying the economics of children’s surgical needs in LMICs (68).

In 2020, the Southern African Development community (SADC) representing 16 member
countries and the AfroSurg Collaborative (69) used a “theory of change” approach to develop a
common vision for improving surgical services in the region. The order of priorities was 1.
Mapping of available services, resources and providers, 2. Quantifying the burden of surgical
disease, 3. Identifying the appropriate number of trainees, 4. Identifying the type of information
necessary for service planning, and 5. Identifying successful strategies for retention of
practitioners. This type of stakeholder buy-in is necessary even when top level national surgical
plans are developed. These strategies were affirmed by surveys of pediatric surgeons serving
SSA (70). NSOAPS (National Surgical Obstetric Anesthesia Plans) or SOTA (Surgery,
Obstetric, Trauma and Anesthesia) (71) with the strong support of the Lancet Commission on
Global Surgery (72), the G4 Alliance (73) and others have been developed in many LMICs. A
multi-pronged approach to financing surgery in the lowest income countries is summarized by
Negrette (74), and engages both the public sector through Development Cooperation (aka
Official Development Assistance), and private sector funding pools (insurance), out of pocket,
philanthropy and corporate social responsibility (CSR). As each country has somewhat different
customs and needs, philanthropy, ODA bi- and multilateral relationships will vary. “...solutions
are general in concept but specific in context”.

**Limitations:** There is little published material about burden of disease, training programs or
international collaboration for many LICs. Information about support from ODAs and other HIC
development engagements that impact surgical care is often packaged within non-surgical programs. Funding is often siloed (for women’s health, fistulas, etc.) even where the surgical facilities and services could be and shared for other surgical cases. NGO outreach activity is mostly unpublished. Additionally, most NGO outreach training is not integrated with formal surgical training programs and is not published.

**Conclusion:** To address the needs for pediatric urology worldwide, a holistic approach should consider the many components in the surgical ecosystem. The large numbers of pediatric urologists with dwindling major surgical case-loads in HICs can be balanced globally if the work is shared. There is an opportunity to collaborate with pediatric urologists and pediatric surgeons in LMICs where the population of children is large and backlogs of cases are overwhelming. As children with congenital urological conditions increasingly grow to adulthood, we must collaborate with adult urologists and general surgeons who will carry their care forward. The potential benefits to both patients and surgeons are many. The emerging field of global surgery provides space for meaningful academic and NGO collaboration, as well as research and political advocacy across disciplines. With the tools and the determination to improve pediatric urology through planning and partnerships, we will improve surgeon education and patient care globally.

**Abbreviations:**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AAGS</td>
<td>Association of Academic Global Surgery</td>
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<tr>
<td>DCP3</td>
<td>Disease Control Priorities, Third Edition</td>
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<td>GICS</td>
<td>Global Initiative for Children’s Surgery</td>
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GSSA Global Surgery Student Association
GU Genitourinary
HIC High-income country
Incision International Student Surgical Network
LIC Low-income country
LMIC Low-and Middle-income countries
NGO Non-government organization
NSOAP National Surgical, Obstetrical and Anesthesiology Plan
ODA Official Development Assistance
SADC South African Development Community
SPU Societies for Pediatric Urology
SSA sub-Saharan Africa
UNITAR United Nations Institute for Training and Research
WOFAPS World Federation of Associations of Pediatric Surgery

Conflict of Interest/Funding: None

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**Figure Legends**

**Fig 1.** Folic acid fortification of grains to prevent neural tube defects. Adapted from: Kancherla V, Wagh K, Pachon H, Oakley GP. A global update on folic acid-preventable spina bifida. https://onlinelibrary.wiley.com/doi/ftftr/10.1002/bdr2.1835

**Fig 2.** Increase in pediatric urology and adult reconstructive urology specialists compared to U.S. population of children under 18 y/o.


**Fig 4.** Access to basic electricity for ≥ 4hours/day. Adapted from: Richie H and Roser M. Our world in data. https://ourworldindata.org/energy-access. cc.
# AUA Census 2017-2020 vs U.S. 2020 Census

<table>
<thead>
<tr>
<th>Primary Specialty</th>
<th>2017 Total</th>
<th>2017 Percent</th>
<th>2020 Total</th>
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<td>Pediatrics</td>
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<table>
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<th>US Population</th>
<th>2010</th>
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<th>2020</th>
<th>% under 18</th>
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<tr>
<td>Total</td>
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<td>331.4 million</td>
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<tr>
<td>Under 18</td>
<td>73.6 million</td>
<td>24%</td>
<td>72.1 million</td>
<td>22.1%</td>
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Weighted Samples from AUA Annual Census
U.S. Census 2020