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Traditional perinatal plant knowledge in Sub-Saharan Africa: Comprehensive compilation and secondary analysis

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A B S T R A C T

Sub-Saharan Africa has rich ethnobotanical heritage of public health relevance within pluralistic systems of perinatal care. Compiling of reported medicinal plant use during pregnancy and postpartum from historical and contemporary sources allowed for analyses directed at i) identification of the most important taxa in relation to key functional purposes, ii) establishing patterns of use, and iii) testing the hypothesis that perinatal plant use is non-random.

Data from 410 publications generated 5979 use reports related to 2122 species from 181 plant families, with 53% of reports published from 2005 to 2020. New species continue to be added at a constant rate. With 86% (67/78) of perinatal-focused papers published since 2005, purposeful research contributes to an increase in overall data availability. For analysis, reports were categorized as i) uterotonic (n = 2596), ii) prenatal (n = 1778, 555 specifically for preventing miscarriage or delaying the onset of labor), iii) lactation and postpartum recovery (n = 1194, 812 as galactagogues), or iv) newborn and infant health (n = 1018). Most frequently reported species per category are discussed in relation to published pharmacological data. Based on congruence among linear regression, negative binomial regression, Bayesian, and Imprecise Dirichlet Model statistics, non-random use includes preference for i) latex-producing families during lactation and postpartum, ii) families differentiating tocolytic and general pregnancy application, and iii) Crassulaceae species for infant umbilicus healing. Significant underuse of the Rubiaceae throughout the perinatal, and for the Apocynaceae and Euphorbiaceae during pregnancy and parturition specifically, suggests avoidance.

Traditional plant knowledge remains relevant to the health and social well-being of Sub-Saharan African populations. Within pluralistic systems, documentation of traditional practices can contribute to complementary approaches and the mediation of potential conflicts with conventional healthcare. Refinement of quantitative and qualitative methodologies for documenting perinatal knowledge, beliefs, and practices can further understanding of the congruence among sociocultural, ecological, molecular, behavioral, and health aspects of women's perinatal use of medicinal plants.

1. Introduction

1.1. Traditional knowledge and perinatal plant use

Knowledge on the traditional use of plants during pregnancy, childbirth, and postpartum is defined by the biological and cultural importance of this distinct time in the lifecycle, and by gender. The knowledge of medicinal plants used during the perinatal period represents past and present selection, presumably guided by physiological properties related to well-defined functional outcomes necessary for reproductive success, as well as by cognitive, ecological, and cultural determinants (Weckerle et al., 2011).

In ethnobotanical inventories, perinatal indications of particular taxa are usually diffused among many other medicinal uses, although a growing number of reviews and primary studies focus on reproductive health more specifically (Ahmed et al., 2018; de Boer and Cotingting, 2014; Motti et al., 2019; James et al., 2018; Yazbek et al., 2016; Towns and Van Andel, 2016). The latter are more likely to highlight knowledge of women, including its transmission and application. Growth in published data over the past two decades provides opportunities to better appreciate the richness of women's knowledge (Sibeko and Johns, 2021; Sibeko et al., 2021), as well as

List of abbreviations: CD, lymphocytes expressing CD (cluster of differentiation) glycoproteins; CNS, central nervous system; COX, cyclooxygenase; IDM, Imprecise Dirichlet Model; IL, interleukin; LPS, lipopolysaccharide; MAPK, mitogen-activated protein kinase; NFkB, nuclear factor kappa-light-chain-enhancer of activated B cells; NO, nitric oxide; PGE, prostaglandin; SSA, Sub-Saharan Africa; TBA, traditional birth attendant; Th, T helper; Treg, T regulatory; TNF α, tumor necrosis factor alpha; UR, use report: a published record of a plant species with one or more uses during the perinatal period

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undertake analysis directed at practical and theoretical questions related to the perinatal period.

The current analysis undertakes to assemble an extensive database of published reports of Sub-Saharan African (SSA) perinatal plant knowledge from historical and contemporary sources. Compilations of ethnomedicinal information at the end of the 20th century (Ayensu, 1978; Bingel and Farnsworth, 1994; Burkill, 1985-2000; Kokwaro, 1976; Neuwinger, 1996, 2000; Watt and Breyer-Brandwijk, 1962) drew on knowledge recorded in the colonial and immediate post-colonial periods, primarily by non-Africans. The subsequent explosion of ethnobotanical investigations (Ahmed et al., 2018; Van Wyk, 2015) led by scientists with direct links to the societies and communities they study has expanded and enriched the knowledge base.

1.2. Perinatal medicinal plant use in traditional and contemporary health

Traditional use of plants and the expertise of Traditional Birth Attendants (TBA) remain essential for primary health of underserviced populations in rural and other areas of SSA (Garces et al., 2019). Although urbanization paralleled by increasing access to modern facilities and skilled professionals profoundly changes perinatal healthcare, across the region some 40% of births occur outside of health facilities (UNICEF, 2021), with many women integrating medicinal plants with modern perinatal care (Nega et al., 2019; Beyene and Beza, 2018). Similarly, contemporary prevalence of medicinal plant use during pregnancy across different African subregions lies minimally within the range of 30–45% (Ahmed et al., 2018). Recent reviews identify contemporary research on medicinal plant use during pregnancy as well as key species (Ahmed et al., 2018; El Hajj and Holst, 2020). Traditional plants used during lactation and the postnatal period have been compiled and reviewed globally including from Africa (Sibeko and Johns, 2021; Sibeko et al., 2021). Population surveys that focus on prevalence of overall use of medicinal plants, primarily in conjunction with healthcare services and/or including urban and middle-class new mothers, do not fully represent the depth and breadth of traditional African medicinal knowledge or practice.

The manner in which women traditionally use plants corresponds with medically recognized stages of pregnancy, labor, and recovery, and with pharmacological mechanisms associated with agents known to mediate these stages (de Boer and Cotingting, 2014). Functional categories that define the field and our analysis include: uterotonic (abortifacient, parturition facilitation, hemorrhage cessation, placenta expulsion); tocolytic (anti-miscarriage, labor onset delay); general health during pregnancy; pain relief; lactation and postpartum recovery (galactagogues, physical and mental health); and newborn care and health of breastfeeding infants. Within pluralistic health systems, consideration of pharmacological and toxicological activities of medicinal plants in a sociocultural context can guide complementary application, as well as appropriate intervention where traditional practices are potentially harmful.

1.3. Non-random selection of plants used perinatally

We use secondary data analysis to address the question whether plant use during the perinatal period reflects specific choice, either by an individual or as embedded in shared cultural knowledge. The non-random theory of medicinal plant selection (Robles Arias et al., 2020) draws on the assumption that physiological and pharmacological activities are attributable to phytochemicals, presumably associated with common taxonomy and phylogenetic relationships. Cognitive, ecological, and cultural historical factors may be at least as important in influencing selection decisions (Weckerle et al., 2011; Savo et al., 2015). Tests of the non-random hypothesis typically compare the number of species per plant family used medicinally within a sample with the number of total species for each of the families in the flora from which the data are obtained. In investigations from different global regions (Van Wyk, 2020; Moerman et al., 1999) and local-scale surveys (Robles Arias et al., 2020; Muleba et al., 2021) families are identified that are utilized more or less than expected on a random basis. The linear regression approach introduced by Moerman (Moerman et al., 1999) has been refined using contingency table/binomial analysis (Bennett and Husby, 2008), negative binomial (Robles Arias et al., 2020), Bayesian (Weckerle et al., 2011), and imprecise probability calculation (using the Imprecise Dirichlet Model (IDM)) (Weckerle et al., 2012) methods. Although methodological strengths and limitations have been debated (Savo et al., 2015; Leonti et al., 2012), such studies can generate explanatory insights and hypotheses. Mapping onto molecular phylogenies can further discern the basis for plant selection for medicinal use (Gras et al., 2021; Pedrosa et al., 2021).

Directly applicable to the SSA scale of the current paper is a recent floristic analysis by Van Wyk (2020) which used linear regression, Bayesian, and IDM methods to identify medicinally over- and underused plant families. We compare our data to that used by van Wyk and extend the analysis to i) include negative binomial regression and ii) consider relative importance for families, genera, and species based on frequency of published reports across perinatal categories. Among the limitations of non-random approaches are the floristic reality that species within a family are not evenly distributed or available within an environment (Robles Arias et al., 2020; Pedrosa et al., 2021); as well existing flora may be only relatively representative (Savo et al., 2015). Frequency of reported use, as it corresponds to both preference for attributes of particular taxa but also to accessibility, provides a measure of the degree to which taxa are relied on in actual practice. On the other hand, failure to utilize taxa that are accessible and/or used medicinally in other contexts suggests selective avoidance during the perinatal.

1.4. Objectives summary

The primary objective of this paper involves compilation of a thorough bibliography and inventory on perinatal plant use in SSA. Analysis of these data seeks to identify the most important taxa in relation to different functional purposes, establish patterns of use, and test the hypothesis that perinatal plant use is non-random. Where available, the functional basis of selection decisions is supported through review of pharmacological investigations. Concurrently, we provide a case study of historical trends and status of ethnomedicinal data collection in SSA.

2. Methods

2.1. Comprehensive review and secondary data analysis

We undertook a review (Fig. 1) of plants used during the perinatal period in relation to health of mothers and infants. The period of interest extends from the onset of pregnancy until approximately six months after parturition (period of postpartum recovery and preweaning lactation). Data were obtained from primary ethnobotanical studies plus compilations and reviews that cite reference sources. Available compilations (Ayensu, 1978; Bingel and Farnsworth, 1994; Kokwaro, 1976; Burkill, 1985-2000; Neuwinger, 1996, 2000; Watt and Breyer-Brandwijk, 1962) cover information published before 2000, including resources not included in electronic databases (primarily before 1974) and generally unavailable electronically. We searched CAB Abstracts (OVID), Medline (OVID), Scopus, and Web of Science databases for primary ethnobotanical studies, surveys, and reviews published from the beginning of databases to 2020. Data included in our tabulation comprise relevant ethnomedicinal uses

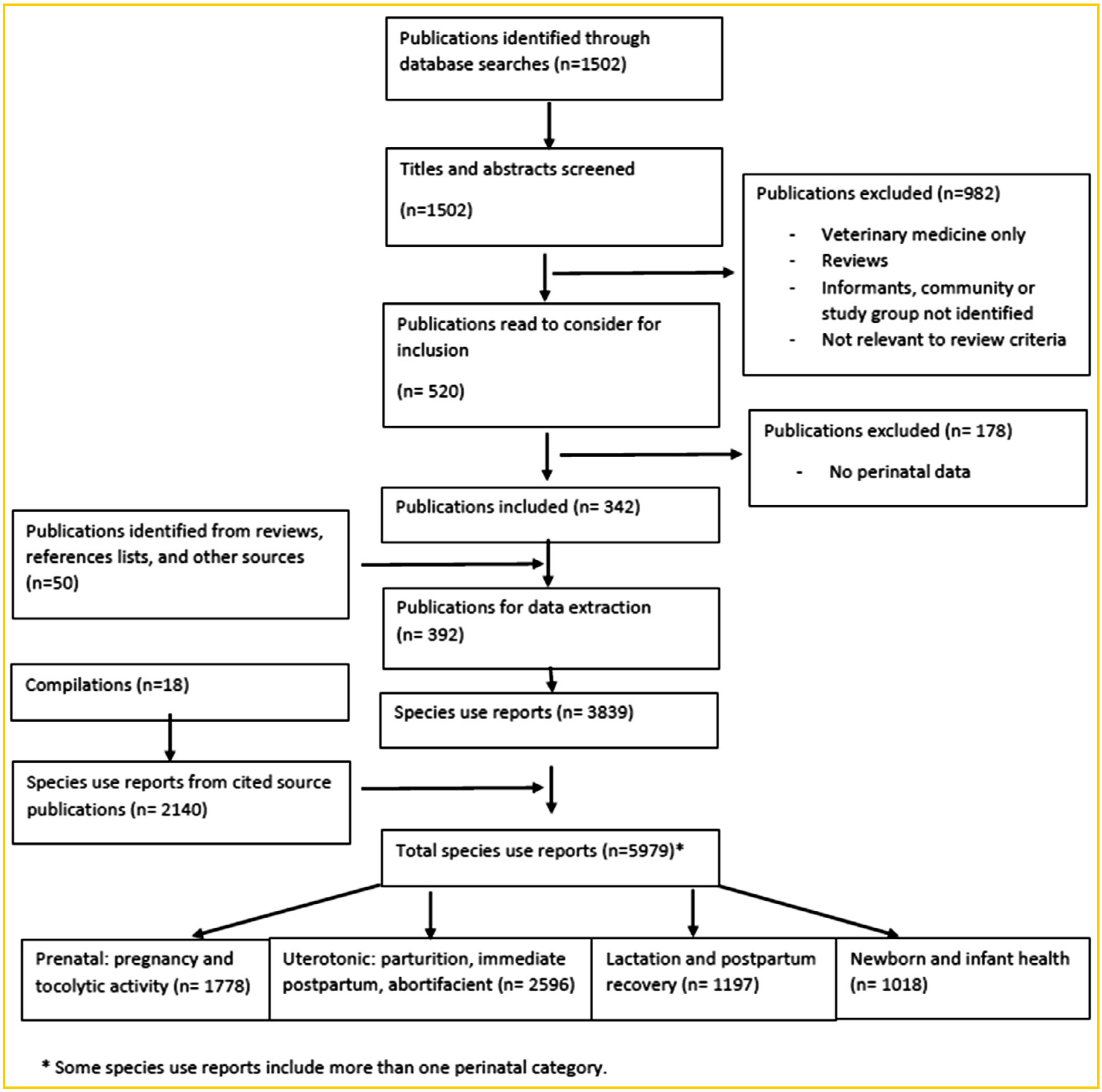

Fig. 1. Flowchart of literature review, data compilation and species report categorization

traceable to source (informants, or in the case of older data to first known publication) and are recorded as species use reports (UR: a published record of a plant species with one or more uses during the perinatal period). Data from compilations and primary sources were cross-referenced, with recognizable duplicates of reports eliminated.

Ethnobotanical studies typically report general medicinal plant use data collected from informant interviews associated with an identified population or group of informants. In order to avoid bias towards particular plants or aspects of perinatal health we excluded studies focused on 1) specific plant families, genera, or species, and 2) diseases or health conditions other than relevant to the perinatal period. Additionally, we excluded 3) infertility treatments, and 4) treatment of only animals, although some relevant human studies overlap with veterinary medicine.

Primary database search terms were ‘medicinal plants’ OR ‘ethnobotany’ cross-referenced with ‘Sub-Saharan Africa’ OR names of each of the countries in SSA, with NOT terms used to exclude specific disease conditions. Titles and abstracts were screened to generate a list of references (Fig. 1) which were read to identify studies meeting inclusion and exclusion criteria. Additional primary studies were identified from bibliographies of review papers that met inclusion and exclusion criteria. Publications that lacked perinatal data were further excluded.

2.2. Data tabulation and pharmacological review

Each plant cited was entered into a database (Appendix A) with one entry for each species per publication (except compilations: each plant cited entered separately). All plant scientific names and family recognition were verified and updated using World Flora Online (2022). Entries were standardized to remove synonyms and obvious errors in spelling. Data recorded included taxonomic information, plant part used, nature of publication, year of publication, geographical location (usually country), and medicinal purpose. Data were further categorized by perinatal period and mechanistic function. Data were tabulated as number of URs and ranked in relation to 4 categories: i) prenatal (pregnancy support, miscarriage prevention), ii) uterotonic (parturition, immediate postpartum, abortifacient), iii) lactation and postpartum recovery, and iv) health of newborns and breastfeeding infants. Pharmacological research for the top ranked

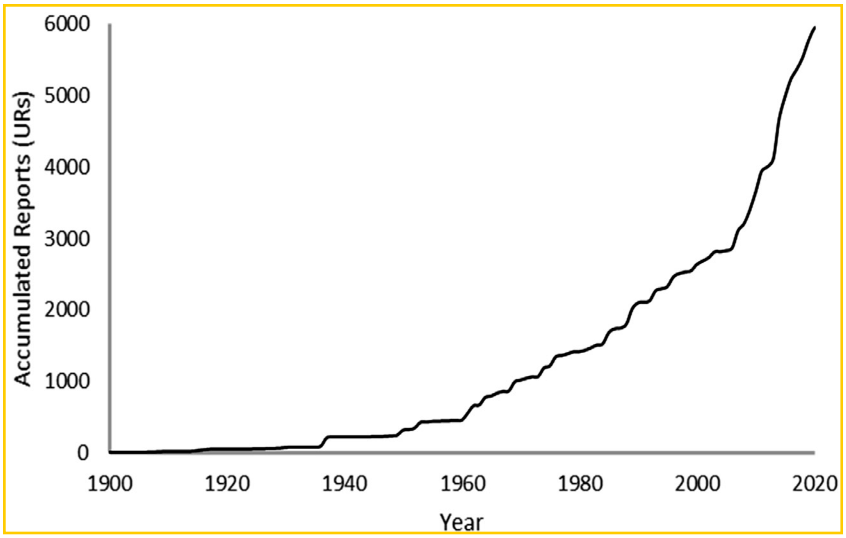

Fig. 2. Accumulation curve of Sub-Saharan reports (URs) of perinatal plant use until 2020.

species was reviewed based on a search of the previously listed databases.

2.3. Non-random selection

Four analytical methods were employed to cross-examine patterns of perinatal plant medicine selection: 1) simple linear regression, 2) negative binomial regression, 3) Bayesian, and 4) Imprecise Dirichlet Modeling (IDM). Firstly, we explored the relationship between number of species in SSA plant families (Van Wyk, 2020) with the number of species per family used for perinatal medicine, running separate analyses for the subcategories: i) prenatal, ii) uterotonic, iii) lactation and postpartum recovery, iv) infant health. Secondly, we examined the relationship between number of recorded medicinal species in SSA plant families (Van Wyk, 2020) with the number of species per family used for perinatal medicine, again separated for usage subcategories. STATA 17.0 (StataCorp, 2021) was used for linear and binomial regression, and Excel was used for Bayesian and IDM analyses.

Regression analyses modeled i) the total number of SSA plant species per family as the independent variable, and ii) the second series modeled the total number of SSA medicinal plant species per family as the independent variable, with number of species per family used for perinatal medicine (different for each usage subcategory) the dependent variable for each model. Families with studentized residuals falling above the 95th and 97.5th percentile of the t-distribution were considered overused and most overused, respectively, and families with studentized residuals falling below the 5th and 2.5th percentile were considered underused and most underused, respectively. Studentized residuals follow Student's *t*-distribution and are more appropriate than raw residuals for identifying outliers (Robles Arias et al., 2020; Savo et al., 2015).

The Bayesian approach followed methods described by Weckerle et al. (2011); we assumed a Uniform (0,1) prior distribution, and used Excel's Inverse beta function and formulas defined by Weckerle et al. to calculate the 95% posterior credible interval of the overall proportion of perinatal plant species used in each of the perinatal usage subcategories, which we compared to the corresponding credible interval for each family. Families were considered underused or overused if their credible interval fell below or above the overall credible interval, respectively. The IDM methods and formulas as described by Weckerle et al. (2012) are similar to the Bayesian approach, but instead of a specific prior distribution applied the parameter value of $s = 4$ which allowed for a wide possibility of priors.

3. Results

3.1. Review and data compilation

Data were collected from 410 publications (Appendix B) (392 primary sources, 18 compilations) and, after cross-referencing sources among compilations, were consolidated to 5979 URs (Appendix A). Compilations accounted for 35.8% (n = 2140) of URs, with 64.2% (n = 3839) from primary ethnobotanical studies and population level surveys. 52.6% of the URs were published in the previous 15 years (2005–2020) representing a strong acceleration in population-level studies since 2005 (Fig. 2). While family and genera are leveling off towards stable asymptotes (Williams et al., 2007), accumulation curves (not shown) demonstrate that new species continue to be reported at a constant rate.

Of the 392 primary studies from which data were obtained, 78 focusing specifically on the perinatal period accounted for 1858 URs (mean= 23.8). The remaining 336 primary studies with 1980 URs averaged only 5.9 per publication. Furthermore, 178 ethnobotanical publications were excluded because they contained no perinatal data. Overall, then, the perinatal represents a small portion of data recorded in broad-spectrum ethnomedicinal studies. On the other hand, with 85.9% (67/78) of perinatal-focused papers published since 2005, purposeful research in this area accounts for much of the increase in overall data availability.

Most URs (Appendix A) are identified to country. Regional delineation for Western and Central Africa corresponded to UN Subregions (UNSD, 2021) while Southern Africa was expanded to include Malawi, Mozambique, Zambia, and Zimbabwe. Eastern Africa comprised Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, South Sudan, Sudan, Tanzania, and Uganda. Although the highest portion of the reports are from Western Africa, URs correspond broadly with current populations (UN Population Division, 2019) for Western (34.5% URs, 39% population), Eastern (30.2, 32), Central (20.1, 17) and Southern (14.4, 11) regions, respectively.

3.2. Pharmacological categorization

In total our data tabulated 2122 species from 181 plant families. The most reported species in each of the four perinatal categories (Appendix A) are summarized in Table 1. For convenience categories are arbitrarily limited to ±20, with cutoffs including all species of the lowest frequency.

Table 1
Perinatal species most reported from Sub-Saharan Africa.

Genus species Authority	Family	Indication reports #	Parts	Main indications	Locations (ranked)
A. Prenatal (pregnancy support, miscarriage prevention)					
Piper umbellatum L.	Piperaceae	14	leaf	support pregnancy, prevent miscarriage	Central, Western
Zingiber officinale Roscoe	Zingiberaceae	14	rhizome	support pregnancy	Eastern (Ethiopia), Western
Ageratum conyzoides (L.) L.	Asteraceae	12	leaf	support pregnancy, prevent miscarriage	Eastern, Western
Allium sativum L.	Amaryllidaceae	12	clove	support pregnancy	Eastern (Ethiopia), Western
Annona senegalensis Pers.	Annonaceae	10	root, bark, leaf	support pregnancy, prevent miscarriage	Western, Eastern, South Africa
Cissampelos mucronata A.Rich.	Menispermaceae	9	root, leaf	support pregnancy, prevent miscarriage	Eastern, Western, Southern
Ficus exasperata Vahl	Moraceae	9	leaf, bark	support pregnancy	Western, Central
Flueggea virosa (Roxb. ex Willd.) Royle	Phyllanthaceae	9	root	support pregnancy, prevent miscarriage	Western, Eastern, Southern
Manihot esculenta Crantz.	Euphorbiaceae	9	root tuber, leaf	support pregnancy	Central, Western
Ruta chalepensis L.	Rutaceae	9	plant	support pregnancy	Ethiopia
Ocimum gratissimum L.	Lamiaceae	9	leaf	support pregnancy, prevent miscarriage	Western, Central
Hoslundia opposita Vahl	Lamiaceae	8	leaf	support pregnancy, prevent miscarriage	Eastern, Western
Ocimum lamiifolium Hochst. ex Benth.	Lamiaceae	8	plant	support pregnancy	Ethiopia
Sida acuta Burm.f.	Malvaceae	8	leaf, root	support pregnancy	Western, Central, Southern
Abelmoschus esculentus (L.) Moench	Malvaceae	7	fruit, leaf	support pregnancy	Western, Central, Eastern
Alchornea cordifolia (Schumach. & Thonn.) Müll.Arg.	Euphorbiaceae	7	root, leaf, bark	prevent miscarriage, support pregnancy	Western, Central, Eastern
Carica papaya L.	Caricaceae	7	leaf, root	support pregnancy	Western, Central, Eastern
Elaeis guineensis Jacq.	Arecaceae	7	fruit, oil	support pregnancy, prevent miscarriage	Western, Central
Hymenocardia acida Tul.	Phyllanthaceae	7	root, leaf	support pregnancy, prevent miscarriage	All regions
Mangifera indica L.	Anacardiaceae	7	bark, leaf	support pregnancy, prevent miscarriage	All regions
Sarcocephalus latifolius (Sm.) E.A. Bruce	Rubiaceae	7	root, bark, leaf	support pregnancy	Western
Sclerocarya birrea (A. Rich) Hochst.	Anacardiaceae	7	bark	support pregnancy, prevent miscarriage	South Africa, Western
Vernonia amygdalina Delile	Asteraceae	7	leaf, root	support pregnancy	Western, Eastern, Central
B. Uterotonic (parturition, immediate postpartum, abortifacient)					
Phytolacca dodecandra L'Hér.	Phytolaccaceae	30	leaf, root	abortifacient	Ethiopia, Eastern, Central
Carica papaya L.	Caricaceae	21	root, leaf, fruit	abortifacient, promote labor	Western, all regions
Ricinus communis L.	Euphorbiaceae	21	root, leaf, seed oil	promote labor, expel placenta, abortifacient	Eastern, all regions
Bidens pilosa L.	Asteraceae	16	leaf, plant	promote labor, other	Eastern, Central
Sida acuta Burm.f.	Malvaceae	16	leaf, root	facilitate childbirth	Western, Central
Cleome gynandra L.	Cleomaceae	15	root, leaf	promote labor	Eastern
Spondias mombin L.	Anacardiaceae	14	leaf, bark	facilitate childbirth, postpartum hemorrhage	Western
Vernonia amygdalina Delile	Asteraceae	14	leaf, root	induce labor, abortifacient, expel placenta	All regions
Jatropha curcas L.	Euphorbiaceae	13	seed, leaf, root	abortifacient, facilitate childbirth, expel placenta	Western, all regions
Musa x paradisiaca L.	Musaceae	13	leaf, root, fruit, sap	promote labor	Western, Eastern
Ocimum gratissimum L.	Lamiaceae	13	leaf	promote labor, abortifacient	Eastern, Western, Central
Momordica charantia L.	Cucurbitaceae	12	seed, fruit, leaf	abortifacient, facilitate childbirth	Western, Central
Abelmoschus esculentus (L.) Moench	Malvaceae	11	leaf, fruit	facilitate childbirth	Western, Central, Southern
Ageratum conyzoides (L.) L.	Asteraceae	11	leaf	facilitate childbirth	Central, Western
Basella alba L.	Basellaceae	11	leaf	induce and quicken labor	Eastern, Central
Asparagus africanus Lam.	Asparagaceae	10	root	facilitate childbirth, expel placenta	Southern, Eastern
Cissampelos mucronata A.Rich.	Menispermaceae	10	root, leaf	facilitate childbirth, postpartum hemorrhage	All regions
Euphorbia hirta L.	Euphorbiaceae	9	leaf, plant	facilitate childbirth	Central, Western, Eastern
Musanga cecropioides R.Br. ex Tedlie	Urticaceae	9	leaf, shoot	facilitate childbirth	Central, Western
Securidaca longipedunculata Fresen.	Polygalaceae	9	root, leaf	facilitate childbirth, abortifacient	All regions
Zehneria scabra Sond.	Cucurbitaceae	9	leaf	facilitate childbirth, abortifacient, expel placenta	Eastern
C. Lactation and Postpartum Recovery					
Euphorbia hirta L.	Euphorbiaceae	28	plant	galactagogue	All regions
Ficus sur Forssk.	Moraceae	19	bark, fruit, seed	galactagogue	All regions
Carica papaya L.	Caricaceae	15	leaf, fruit, latex	galactagogue	Western, Central
Milicia excelsa (Welw.) C.C.Berg	Moraceae	13	bark, leaf, latex	galactagogue	Central, Western, Eastern
Kigelia africana (Lam.) Benth.	Bignoniaceae	12	fruit, bark, leaf	galactagogue, postpartum recovery	Western, Southern, Central
Musanga cecropioides R.Br. ex Tedlie	Urticaceae	11	sap	galactagogue	Central, Western
Xylopia aethiopica (Dunal) A.Rich.	Annonaceae	10	fruit, seed, leaf	postpartum recovery, galactagogue	Western
Arachis hypogaea L.	Fabaceae	9	seed	galactagogue	Western, Central, Southern
Cynanchum viminale (L.) L.	Apocynaceae	9	plant	galactagogue	Southern
Elaeis guineensis Jacq.	Arecaceae	9	seed, oil	galactagogue, postpartum recovery	Western, Central
Manihot esculenta Crantz	Euphorbiaceae	9	root tuber, leaf	galactagogue	Central, Western, Eastern

(*continued*)

Table 1 (*Continued*)

Genus species Authority	Family	Indication reports #	Parts	Main indications	Locations (ranked)
Ozoroa insignis Delile	Anacardiaceae	9	root, bark, leaf	galactagogue	Tanzania, Western, Central
Tetrapleura tetraptera (Schum. & Thonn.) Taub.	Fabaceae	8	fruit	postpartum infection, galactagogue	Western, Central
Aframomum melegueta K.Schum.	Zingiberaceae	7	seed	galactagogue, pain	Western, Central
Brenandendron donianum (DC.) H. Rob.	Asteraceae	7	bark, shoot	galactagogue	Central, Western
Guiera senegalensis J.F.Gmel.	Combretaceae	7	leaf	galactagogue	Western, Central
Pterocarpus angolensis DC.	Fabaceae	7	bark	galactagogue, postpartum recovery	Southern, Tanzania, Central
Ricinus communis L.	Euphorbiaceae	7	leaf	galactagogue	All regions
Secamone afzelii (Roem. & Schult.) K.Schum.	Apocynaceae	7	leaf, plant	galactagogue	Western
Vernonia amygdalina Delile	Asteraceae	7	leaf	galactagogue	Western, Eastern, Central
D. Infant health					
Bryophyllum pinnatum (Lam.) Oken	Crassulaceae	13	leaf	healing of navel	Western, Central, Eastern
Kalanchoe crenata (Andrews) Haw.	Crassulaceae	9	leaf	healing of navel, infant care	Western, Central, Eastern
Aframomum melegueta K.Schum.	Zingiberaceae	7	fruit, seed, leaf	close fontanelle, infectious conditions	Central, Western
Ocimum gratissimum L.	Lamiaceae	7	leaf	infant care	Western, Central, Eastern
Piper umbellatum L.	Piperaceae	7	leaf	infant care	Central
Annona senegalensis Pers.	Annonaceae	6	root, bark	infant care, close fontanelle	South Africa, Western
Ficus sur Forssk.	Moraceae	6	bark, leaf, root	infant care	Western, Southern
Xylopia aethiopica (Dunal) A.Rich.	Annonaceae	6	seed, fruit	gastrointestinal, infant care	Western
Bauhinia reticulata DC.	Fabaceae	5	leaf	nutritional tonic for newborn	Western
Bidens pilosa L.	Asteraceae	5	leaf	infant care	South Africa, Western, Eastern
Calotropis procera (Aiton) Dryand.	Apocynaceae	5	leaf, latex	umbilical cord, infant care	Western
Clausena anisata (Willd.) Hook.f. ex Benth.	Rutaceae	5	leaf	newborn tonic	South Africa, Western, Eastern
Harungana madagascariensis Lam. ex Poir.	Hypericaceae	5	bark, leaf	infant care	Western, Eastern, Southern
Momordica charantia L.	Cucurbitaceae	5	leaf	infant care	Western, Central
Sarcocephalus latifolius (Sm.) E.A. Bruce	Rubiaceae	5	bark, root	infant care	Western

The greatest number of URs correspond to the Uterotonic category (n = 2596). Of these, 1426 related specifically to parturition (inducing or facilitating labor), followed by abortifacient (n = 688), expulsion of placenta (n = 374), and immediate postpartum (hemorrhage, pain, expulsion of lochia) (n = 290), respectively. The Prenatal category (n = 1778) combines URs for general (support of a successful pregnancy from the first month until childbirth) (n = 1331) use with those specifically for preventing miscarriage or delaying the onset of labor (n = 555). Many plants in the category are reported simply as "pregnancy" which, while perhaps supporting health through nutrition, alleviation of nausea, or other symptoms, could also mean preventing premature adverse outcomes. "Pregnancy" and prevention of miscarriage could each correspond to tocolytic activity, but also potentially embrace a range of mechanisms including alleviation of infection (Brown et al., 2013). Anti-abortive or preventing miscarriage activity was specifically attributed to 422 species, while 790 species were identified with other contributions to successful pregnancy or were ambiguous. Likewise, Lactation and Postpartum Recovery are confounded by the manner in which ethnobotanical data are translated and/or recorded in abbreviated terms (Sibeko and Johns, 2021). Of the 1194 URs in this category, 812 are specifically identified as galactagogues or directly related to lactation, with 402 attributed other (specific or general) use in the postpartum period. The Newborn and Infant Health category (n = 1018) included a wide range of uses ranging from specific functions such as the healing of the navel and closing of fontanelles to multiple health issues coincident with the preweaning period.

3.3. Non-random selection

Summaries of families for which the number of species used significantly over- or under-represents that expected based on random selection are tabulated in Table 2. Data for individual statistical tests are provided in Appendices C-E. Consistent with previous studies (Van Wyk, 2020), families identified by linear regression, Bayesian and IDM approaches overlap broadly, with differences attributable to the recognized bias of linear regression to large families and greater sensitivity of the other methods to small family designation. While the negative binomial regression was generally consistent with linear regression and other methods, the largest families (with concomitant large residuals) were often non-significant, or rather than being over-represented were under-represented. Such ambiguous families are placed at the end of the lists in Table 2.

Our data collection method only indirectly tabulates species, with families (usually large) with multiple reports being of primary importance in relation to population health. Reports totals do vary in relation to species number (linear regression, r^2 = 0.97), although notable families containing one or more widely-reported species (Table 1) predicably deviate from this relationship in having the largest residuals (*cf.* Euphorbiaceae, Moraceae, Malvaceae, Anacardiaceae, Cucurbitaceae, Caricaceae). We ask the questions as to which of the most widely-used families in perinatal care are being selected beyond i) simply their floristic presence or ii) their recognized contributions as medicinal plants in general. For each perinatal category (and the perinatal total), Table 2 lists the families significant by regression (studentized residuals fall above 97.5th percentile or below 2.5th percentile of Student's t-distribution) plus additional families from Bayesian and IDM approaches (95% posterior credible interval for the family falls above or below the overall credible interval) for which report number at least equals the minimum reports corresponding to regression significance. Families are presented in rank order of reports. Smaller families over-utilized by Bayesian and IDM analyses, but contributing relatively few reports, while less important in health practice can be targets for pharmacological or other research. These are identifiable in Appendix E.

The significant families do vary among categories, suggesting medicinal plant use during the perinatal period is non-random. Specific examples are discussed further below. The Solanaceae stands out as being widely over-used across categories and in the perinatal total, with the Amaranthaceae, Cucurbitaceae and Phyllanthaceae also showing cross-category perinatal use. With the exception of

Table 2

Summary of statistical analyses for subcategories and perinatal totals in relation to i) African species and ii) African medicinal species. Lists for over- and underused families are ranked according to number of reports and species, respectively. Families listed below dotted lines are underused in the negative binomial analysis but overused by linear regression (and sometimes other) analysis. Superscripts: [a] linear regression ($p > 97.5$ or < 2.5), [b] negative binomial regression ($p > 97.5$ or < 2.5), [c] Bayesian, [d] IDM. * Additional underused families by Bayesian analysis (Appendix E).

Family		Family		Family		Family		Family		Family	
Prenatal								**Uterotonic**			
African species		African medicinal species						African species		African medicinal species	
				Tocolytic		General Pregnancy					
OVER-USED	Report#		Report#		Report#		Report#		Report#		Report#
Lamiaceae[acd]	84	Lamiaceae[a]	84	Phyllanthaceae[abcd]	17	Lamiaceae[a]	59	Malvaceae[acd]	186	Cucurbitaceae[ac]	75
Malvaceae[acd]	76	Amaranthaceae[abcd]	40	Anacardiaceae[abcd]	17	Amaranthaceae[abcd]	30	Euphorbiaceae[a]	133	Solanaceae[acd]	58
Anacardiaceae[bcd]	43	Rutaceae[b]	35	Piperaceae[c]	14	Solanaceae[ac]	24	Lamiaceae[acd]	95	Urticaceae[b]	32
Amaranthaceae[bcd]	40	Solanaceae[abc]	33	Combretaceae[a]	13	Cucurbitaceae[ac]	22	Cucurbitaceae[abcd]	75	Bignoniaceae[abcd]	29
Phyllanthaceae[cd]	40	Menispermaceae[b]	28	Amaranthaceae[abc]	11	Menispermaceae[bcd]	19	Solanaceae[abcd]	58	Pedaliaceae[bc]	26
Annonaceae[cd]	39	Zingiberaceae[b]	28	Capparaceae[b]	8	Bignoniaceae[bc]	18	Anacardiaceae[bcd]	52	Sapindaceae[bc]	25
Combretaceae[abcd]	38	Bignoniaceae[b]	23	Musaceae[c]	7	Piperaceae[c]	14	Amaranthaceae[cd]	49	Xanthorrhoeaceae[b]	22
Solanaceae[abcd]	33	Piperaceae[c]	18	Rutaceae[b]	7	Pedaliaceae[bc]	7	Moraceae[bcd]	46	Zingiberaceae[bd]	19
Moraceae[cd]	31	Rosaceae[b]	7	Zingiberaceae[b]	6	Ranunculaceae[c]	7	Vitaceae[cd]	38	—————	
Vitaceae[cd]	29	—————		—————		Chrysobalanaceae[bc]	6	Annonaceae[cd]	33	Fabaceae[a]	333
Zingiberaceae[cd]	29	Fabaceae[a]	211	Fabaceae[a]	76	Rosaceae[bc]	6	Phyllanthaceae[d]	32	Asteraceae[a]	193
Cucurbitaceae[abcd]	28	Asteraceae[a]	148	Asteraceae[a]	59	—————		Urticaceae[cd]	32	Malvaceae[acd]	186
Menispermaceae[bcd]	28	Malvaceae[a]	76			Asteraceae[a]	99	Phytolaccaceae[c]	31		
—————						Malvaceae[a]	73	Bignoniaceae[bcd]	29		
Fabaceae[acd]	211							Combretaceae[bcd]	27		
								Meliaceae[cd]	27		
								—————			
								Fabaceae[acd]	333		
UNDER-USED	Species#		Species#		Species#		Species#		Species#		Species#
Asteraceae[b]	4250	Rubiaceae[abcd]	318	Rubiaceae[abcd]	318	Fabaceae[b]	576	Asteraceae[b]	4250	Rubiaceae[abcd]	318
Rubiaceae[b]		Euphorbiaceae[b]	180	Malvaceae[b]	202	Rubiaceae[abc]	318	Rubiaceae[bc]	2754	Euphorbiaceae[b]	180
Poaceae[acd]	2031	Apocynaceae[b]	167	Euphorbiaceae[b]	180	Euphorbiaceae[ab]	180	Poaceae[acd]	2031	Apocynaceae[ab]	167
Orchidaceae[abcd]	1897	Asparagaceae[a]	90	Apocynaceae[a]	167	Acanthaceae[a]	103	Orchidaceae[abcd]	1897	Sapotaceae[ac]	44
Aizoaceae[abcd]	1688	Poaceae[a]	85	Asparagaceae[a]	90	Asparagaceae[a]	90	Aizoaceae[abcd]	1688	Celastraceae[ac]	40
Iridaceae[abcd]	1381	Sapotaceae[a]	44	Sapotaceae[a]	44	Meliaceae[abc]	47	Iridaceae[abcd]	1381	Scrophulariaceae[a]	38
Cyperaceae[acd]	1335	Verbenaceae[ac]	39	Scrophulariaceae[ab]	38	Scrophulariaceae[ac]	38	Cyperaceae[acd]	1335	Orchidaceae[acd]	34
Scrophulariaceae[acd]	1045	Scrophulariaceae[ac]	38	Boraginaceae[a]	33	Geraniaceae[c]	20	Scrophulariaceae[cd]	1045	—————	
Ericaceae[cd]	1021	Thymelaeaceae[c]	26	—————		—————		Ericaceae[acd]	1021	Fabaceae[b]	576
Campanulaceae[cd]	617	Geraniaceae[c]	20	Fabaceae[b]	576	Asteraceae[b]	314	Campanulaceae[cd]	617	Asteraceae[b]	314
Crassulaceae[c]	531	—————		Asteraceae[b]	314	Malvaceae[b]	202	Proteaceae[bcd]	443	Malvaceae[b]	202
Proteaceae[c]	443	Fabaceae[b]	576					Restionaceae[c]	354		
Geraniaceae[bc]	374	Asteraceae[b]	314					Gesneriaceae[c]	155		
Restionaceae[c]	354	Malvaceae[b]	202					—————			
Orobanchaceae[c]	307							Fabaceae[b]	5220		
Santalaceae[c]	307										
Thymelaeaceae[c]	294										
—————											
Fabaceae[b]	5220										

(continued on next page)

Table 2 (*Continued*)

Family		Family		Family		Family		Family		Family	
Postpartum				**Infant**				**Perinatal Total**			
African species		African medicinal species		African species		African medicinal species		African species		African medicinal species	
OVER-USED	Report#		Report#		Report#		Report#		Report#		Report#
Euphorbiaceae[acd]	89	Apocynaceae[acd]	87	Malvaceae[acd]	44	Solanaceae[a]	31	Malvaceae[acd]	329	Solanaceae[ac]	132
Apocynaceae[acd]	87	Moraceae[abcd]	62	Solanaceae[abcd]	31	Crassulaceae[b]	26	Euphorbiaceae[acd]	301	Amaranthaceae[acd]	120
Moraceae[abcd]	62	Sapotaceae[abcd]	30	Annonaceae[bcd]	25	Amaranthaceae[abc]	24	Lamiaceae[acd]	213	Bignoniaceae[bc]	71
Malvaceae[acd]	50	Anacardiaceae[a]	27	Amaranthaceae[abcd]	24	Asparagaceae[a]	23	Moraceae[bcd]	138	Urticaceae[bc]	67
Sapotaceae[bcd]	30	Solanaceae[acd]	23	Combretaceae[bcd]	20	Phyllanthaceae[abc]	17	Solanaceae[abcd]	132	Amaryllidaceae[b]	64
Anacardiaceae[bcd]	27	Arecaceae[bc]	19	Moraceae[c]	18	Amaryllidaceae[abc]	16	Cucurbitaceae[bcd]	127	Xanthorrhoeaceae[abcd]	43
Rutaceae[c]	25	Zingiberaceae[c]	13	Phyllanthaceae[abcd]	17	Xanthorrhoeaceae[b]	10	Anacardiaceae[bcd]	122	Arecaceae[c]	42
Solanaceae[abcd]	23	Piperaceae[bd]	11	Cucurbitaceae[abcd]	15	Piperaceae[c]	9	Amaranthaceae[cd]	120	Araceae[b]	31
Bignoniaceae[cd]	22	Amaryllidaceae[bc]	11	———————–		Urticaceae[b]	8	Annonaceae[cd]	102	Brassicaceae[c]	18
Cucurbitaceae[cd]	21	Araceae[b]	10	Fabaceae[acd]	135	—————————–		Phyllanthaceae[cd]	98	Rosaceae[c]	17
Arecaceae[cd]	19	Musaceae[c]	10			Fabaceae[a]	135	Combretaceae[abcd]	94	Araliaceae[bd]	16
Amaranthaceae[cd]	18	————————						Vitaceae[cd]	81	—————————-	
Phyllanthaceae[bcd]	18	Euphorbiaceae[a]	89					Bignoniaceae[cd]	71	Fabaceae[a]	733
Urticaceae[cd]	18							Urticaceae[cd]	67	Asteraceae[a]	423
Combretaceae[bcd]	17							Zingiberaceae[cd]	61	Malvaceae[a]	329
————————								Meliaceae[bcd]	56		
Fabaceae[a]	119							Menispermaceae[cd]	56		
								Sapindaceae[cd]	56		
								————————–			
								Fabaceae[acd]	733		
UNDER-USED	Species#		Species#		Species#		Species#		Species#		Species#
Asteraceae[b]	4250	Fabaceae[b]	576	Asteraceae[b]	4250	Rubiaceae[abc]	318	Asteraceae[b]	4250	Rubiaceae[acd]	318
Rubiaceae[c]	2754	Rubiaceae[abcd]	318	Orchidaceae[abcd]	1897	Asteraceae[b]	314	Orchidaceae[abcd]	1897	Annonaceae[a]	72
Poaceae[acd]	2031	Asteraceae[b]	314	Aizoaceae[acd]	1688	Euphorbiaceae[b]	180	Rubiaceae[cd]	2754	Euphorbiaceae[b]	180
Orchidaceae[abcd]	1897	Malvaceae[b]	202	Iridaceae[abcd]	1381	Malvaceae[b]	73	Poaceae[acd]	2031	Apocynaceae[b]	167
Aizoaceae[abcd]	1688	Acanthaceae[a]	103	Cyperaceae[acd]	1335	Vitaceae[a]	56	Aizoaceae[abcd]	1688	Scrophulariaceae[acd]	38
Acanthaceae[c]	1587	Annonaceae[a]	72	Scrophulariaceae[acd]	1045	Sapotaceae[ac]	44	Acanthaceae[cd]	1587	Melastomataceae[ac]	35
Iridaceae[abcd]	1381	Scrophulariaceae[abc]	38	Ericaceae[abcd]	1021	Scrophulariaceae[a]	38	Iridaceae[abcd]	1381	Orchidaceae[ac]	34
Cyperaceae[acd]	1335	Thymelaeaceae[ac]	26	Campanulaceae[bc]	617	Melastomataceae[a]	35	Cyperaceae[cd]	1335	Thymelaeaceae[ac]	26
Scrophulariaceae[abcd]	1045	Salicaceae[a]	23	Proteaceae[c]	443	Orchidaceae[a]	34	Scrophulariaceae[acd]	1045	Clusiaceae[c]	20
Ericaceae[cd]	1021	————————		Geraniaceae[c]	374	Geraniaceae[b]	20	Ericaceae[abcd]	1021	Iridaceae[c]	16
Campanulaceae[c]	617	Euphorbiaceae[b]	180	Restionaceae[c]	354	———————————-–		Campanulaceae[cd]	617	Malpighiaceae[c]	12
Proteaceae[c]	443			———————–		Fabaceae[b]	576	Proteaceae[cd]	443	Caryophyllaceae[c]	10
Restionaceae[c]	354			Fabaceae[b]	5220			Restionaceae[cd]	354	Begoniaceae[c]	9
————————								————————–		Melianthiaceae[c]	6
Fabaceae[b]	5220							Fabaceae[b]	5220	—————————-	
								*		Fabaceae[b]	576
										Asteraceae[b]	314
										Malvaceae[b]	202

Amaranthaceae, all are among the most recognized SSA medicinal families (Van Wyk, 2020).

Under-used families (Table 2) are of interest as indicators of exclusion, with large ones such as Orchidaceae and Poaceae well-recognized as having relatively few medicinal species (Van Wyk, 2020). Here we ask the questions: i) which families are selected less than expected in relation to i) their floristic size or, but perhaps more interestingly, ii) their recognized medicinal contribution beyond perinatal application. We rank underused families identified among the tests according to i) their number of Africa species or ii) their number of reported African medicinal species. Exceptional in our data is the underuse of the Rubiaceae; that this is a family specifically overused for general medicinal application in SSA (Van Wyk, 2020) suggests active perinatal avoidance.

4. Discussion

A growing number of ethnobotanical studies originating in SSA over the past 15 years (Fig. 1, Appendix B), and the resulting accumulation of ethnomedicinal knowledge, provide new opportunities for secondary data analysis. In addition to documenting this heritage, knowledge compilations support theoretical and practical insights. Understanding patterns of perinatal plant use has immediate application for healthcare within the pluralistic systems that remain widespread across SSA, for prioritizing plants for ancillary research, and for understanding the physiological, ecological, cultural, and behavioral determinants of human health and disease, both past and present.

4.1. Overview of SSA perinatal medicinal plant knowledge

We tabulated reports of 2122 species, 978 genera, and 181 families with perinatal application in SSA (Appendix A). These numbers greatly exceed the 274 species (only 20 from more than one article) and 87 families previously reported from all of Africa (Ahmed et al., 2018). Differences can be attributed to the narrower focus of Ahmed et al. on studies documenting prevalence coincident with actual use and engagement with healthcare facilities, as well as a limit on publications from 1987 to 2017. In addition to drawing on publications from over 120 years, the current study focused broadly on knowledge reports, whether or not this coincided with documented use. Additionally, we include postpartum use of plants in our review.

While the large number of taxa recorded (Appendix A) suggest that much of perinatal medicinal plant use is random, patterns identifying taxa for specific purposes (often across widespread geographical areas) support the argument that traditional knowledge is both shared and purposeful. Reproduction is defined by unambiguous outcomes and pragmatic knowledge of essential relevance to all communities. Tabulation of the data we assembled into categories that are widely recognized in traditional and scientific medicine quantitatively supports that overall use of plants during the perinatal period across SSA is non-random.

4.2. Perinatal categories: Patterns and mechanisms of plant use

4.2.1 Prenatal

Support for health and well-being of the mother and for development of the fetus over nine months draws on a variety of potential medicinal plant activities. While several plant taxa have widespread use during this period, patterns are harder to discern. Citations may mention specific health purpose, but many others relate to just “pregnancy”. Saying something “supports a healthy pregnancy” does not differentiate general health of the mother or fetus from prevention of miscarriage.

Pregnancy represents a vulnerable state for mothers, and metabolic and pathological conditions such as preeclampsia, gestational diabetes, and malnutrition lead to poor pregnancy outcomes (Brown et al., 2013). Pregnancy also suppresses maternal immune system, with infection an important risk factor for miscarriage in all stages of pregnancy. Because infectious diseases present exceptional risk in SSA (Naghavi et al., 2017), antimalarial, antimicrobial and related activities of medicinal plants potentially contribute to reproductive success. Other plants may offer symptom relief in relation to nausea, vomiting, hemorrhage, pain, or fever.

Among the species in Table 1A, experimental investigations have reported tocolytic or activity mediating uterine contractions for *Cissampelos mucronatata* (Maroyi, 2020), *Ficus exasperata,* and *Zingiber officinale* (Bafor and Kupittayanant, 2020). Several plants show a broad spectrum of effects relevant to the prenatal period, specifically antimicrobial, antimalarial, antidiabetic, antihypertensive, and immunomodulatory activities (Table 3). Meta-analyses of clinical studies support use of *Zingiber officinale* for alleviating nausea of early pregnancy (Khorasani et al., 2020). The food plants *Abelmoschus esculentus, Carica papaya, Mangifera indica,* and *Manihot esculenta* offer nutritional benefits, while oil of *Elaeis guineensis*, as well as being a source of fatty acids, is often a vehicle for other medicinal plants (*cf.* Towns and Van Andel, 2016).

Among the most widely reported families for prenatal use, the Rutaceae stands out as significant in relation to number of species in other perinatal categories (Table 2) or to medicinal species in general use across SSA (Van Wyk, 2020). Also noteworthy is the over-use of the Menispermaceae in comparison to other perinatal categories. With the objective of distinguishing families that might be selected for preventing miscarriage from those with more general pregnancy purpose, we undertook the same statistical analyses with stratified data. Here (Table 2), the Rutaceae as well as the Anacardiaceae, Capparaceae, Combretaceae, Musaceae, Phyllanthaceae, and Zingiberaceae were significant only in relation to tocolytic purposes, while the Menisiperaceae, as well as the Bignoniaceae, Cucurbitaceae, Rosaceae, and Solanaceae, were specifically significant in relation to general pregnancy use.

The Apocynaceae and Euphorbiaceae are under-used in the prenatal period and overall in perinatal totals (with exceptions during the postpartum (see Section 4.2.3)). While both are important medicinal families in SSA (Van Wyk, 2020), the fact they have notable toxicity (Alonso-Castro et al., 2017) may explain their relative avoidance during pregnancy and parturition.

4.2.2. Uterotonic

In addition to representing the largest portion of the URs ($n = 2596$), uterotonic activity relates to functional outcomes specific to pregnancy and childbirth that have oxytocic and other physiological mechanisms. Several species stand out as being widely used across multiple regions (Table 1B), primarily for facilitating childbirth through labor induction, acceleration, or for prolonged labor. Abortion induction, cessation of postpartum hemorrhage, and expulsion of the placenta further point to plants that may act through oxytocic mechanisms. Plants for which known oxytocic activity supports uterotonic use include *Bidens pilosa* (Frida et al., 2008; Nikolajsen et al., 2011), *Carica papaya* (Alara et al., 2020), *Cissampelos mucronata* (Lampiao et al., 2018), *Musanga cecropioides* (Larsen et al., 2016), *Ocimum gratissimum* (Attah et al., 2012), *Ricinus communis* (Kaingu et al., 2012), and *Vernonia amygdalina* (Attah et al., 2012). *Spondias mombin* has been reported to induce labor through other mechanisms (Barfor and Kupittayanant, 2020). *Phytolacca dodecandra* is an effective abortifacient in rats (Namulindwa et al., 2015). Evidence of anti-implementation effects may explain use of *Momordica charantia* seed (Grover and Yadav, 2004; Amah and Yama, 2012) and *Ocimum gratissimum* (Sripriya et al., 2011) in early abortion. For all of the above species, experimental data are of a preliminary nature and limited to *in vitro* and rodent studies.

Table 3
Pregnancy supporting activities of plants most reported for prenatal use in Sub-Saharan Africa.

Plant	Tocolytic	Anti-microbial activity / Infectious diseases	Antidiabetic	Antihypertensive	Other
Abelmoschus esculentus Malvaceae			Elkhalifa et al., 2021		
Ageratum conyzoides Asteraceae		antimalarial, other antiprotozoal (Yadav et al., 2019; Nour et al., 2010)			
Alchornea cordifolia Euphorbiaceae		antimicrobial, antimalarial (Boniface et al., 2016)	Boniface et al., 2016		
Allium sativum Amaryllidaceae		antimicrobial (Batiha et al., 2020)	Batiha et al., 2020	Batiha et al., 2020	
Annona senegalensis Annonaceae		antimicrobial, antimalarial, other antiprotozoal (Quilez et al., 2018)			
Carica papaya Caricaceae		antimicrobial, antimalarial (Alara et al., 2020)	Alara et al., 2020		
Cissampelos mucronata Menispermaceae	Maroyi, 2020	antimicrobial, antimalarial, antiprotozoal (Maroyi, 2020)			
Ficus exasperata Moraceae	Barfor and Kupittayanant, 2020	antimicrobial (Tekwu et al., 2012)	Ahmed et al., 2012	Oboh et al., 2014	
Flueggea virosa Phyllanthaceae		antimicrobial (Ajaib et al., 2020), antimalarial (Singh et al., 2017)			
Hoslundia opposita Lamiaceae		antimalarial (Koffi et al., 2020)	Akolade et al., 2014		
Hymenocardia acida Phyllanthaceae		antimicrobial (Starks et al., 2014), antimalarial (Tuenter et al., 2016)	Mohammed et al., 2014	Manga et al., 2013	
Mangifera indica Anacardiaceae		antimicrobial, antimalarial (Kumar et al., 2021; Batool et al., 2018)	Kumar et al., 2021; Batool et al., 2018		immunomodulatory (Kumar et al., 2021; Batool et al., 2018)
Ocimum gratissimum Lamiaceae		antimalarial (Abiodun et al., 2011, antimicrobial (Melo et al., 2019)	Antora and Salleh, 2017	Shaw et al., 2017	
Ocimum lamiifolium Lamiaceae		antimalarial (Kefe et al., 2016)			
Piper umbellatum Piperaceae		antifungal, antimicrobial, antimalarial (Roersch, 2010)			antioxidant (Roersch, 2010)
Ruta chalepensis Rutaceae		antimicrobial (Coimbra et al., 2020)	Coimbra et al., 2020		
Sclerocarya birrea Anacardiaceae		antimicrobial, antimalarial (Ojewole et al., 2010)	Ojewole et al. 2010		
Sida acuta Malvaceae		antimicrobial, antimalarial (Dinda et al., 2015; Rodrigues and de Oliveira, 2020)	Dinda et al., 2015		
Vernonia amygdalina Asteraceae		antimicrobial, antimalarial (Toyang and Verpoorte, 2013; Danladi et al., 2018)	Toyang and Verpoorte, 2013; Danladi et al., 2018		immunomodulatory (Toyang and Verpoorte, 2013)
Zingiber officinale Zingiberaceae	Barfor and Kupittayanant, 2020				anti-nausea (Khorasani et al., 2020)

Analgesic activity within *in vivo* nocioception models has been reported for *Abelmoschus esculentus* (Romdhane et al., 2020), *Ageratum conyzoides* (Yadav et al., 2019), *Asparagus africanus* (Hassan et al., 2008), *Basella alba* (Abioye et al., 2019), *Bidens pilosa* (Fotso et al., 2014), *Carica papaya* L. (Ahmed et al., 2018), *Cleome gynandra* (Ghogare et al., 2009), *Euphorbia hirta* (Olatoyan-Layonu et al., 2020), *Jatropha curcas* (Cavalcante et al., 2020), *Momordica charantia* (Patel et al., 2010), *Musa x paradisiaca* (Rao et al., 2014), *Musanga cecropioides* (Cordiero et al., 2020), *Ocimum gratissimum* (Uritu et al., 2018), *Ricunus communis* (Abdul et al., 2018), *Sida acuta* (Prasad et al., 2020), and *Vernonia amygdalina* (Asante et al., 2019).

A number of genera are widely used across all 4 regions (*cf.* Section 4.4 and Table 1). On the other hand, *Phytolacca dodecandra* is mainly used in Ethiopia. At the family level the Cucurbitaceae, Solanaceae, Urticaceae, Bignoniaceae, Pedaliaceae, and Sapindaceae stand out as reported more than expected in comparison to both total and medicinal species in the African flora. In relation to the overall flora, Malvaceae, Lamiaceae, and several less-reported families were significant in multiple tests. Euphorbiaceae, another family with large number of species and reports, was significant in comparison to total species only in linear regression. The Phytolaccaceae was significant only in the Bayesian comparison to African species, reflecting the significant use of this smaller family, particularly of the genus *Phytolacca*. This is congruent with experimental evidence supporting *P. dodecandra*, specifically, as an abortifacient. Pharmacological explanations are not readily apparent in explaining selection of other uterotonic families. The Malvaceae is mucilage producing, which as associated with a lubricant function in easing birth passage may represent doctrine of signatures; similarly, the Cucurbitaceae is characterized both by abundant phloem sap as well as bitterness. As previously noted, these families are widely used perinatally rather than specifically as uterotonics.

4.2.3. Lactation and postpartum recovery

The majority of plants utilized in relation to lactation and postpartum recovery are specifically identified as galactagogues. In Table 1C, 10 of the 20 most widely reported species are latex-producing and/or in families characterized by latex (Apocynaceae, Caricaceae, Euphorbiaceae, Moraceae), a pattern in SSA linked to doctrine of signatures

(Cordeiro et al., 2020; Sibeko and Johns, 2021). Among over-used families, those most widely reported include latex-producing Apocynaceae, Moraceae, Sapotaceae, and Euphorbiaceae (linear regression). Both the Apocynaceae and Sapotaceae are under-used among African medicinal plants as uterotonics and in the prenatal category, with the Euphorbiaceae also under-used prenatally (Section 4.2.1), suggesting their selection for postpartum and lactation application is highly specific. Conversely, among the under-used families in the postpartum category are two of the most important African medicinal families (Van Wyk, 2020), Annonaceae and Rubiaceae, suggesting active avoidance.

Other forms of doctrine of signatures are evident in the association by shape of fruits of *Kigelia africana* or *Carica papaya* with female breasts, while immature seeds of *Arachis hypogoea* have a milky endosperm. Just because a plant is associated with doctrine of signatures does not mean it cannot have pharmacological properties with functional significance. Indeed, doctrine of signatures can be a mnemonic device for communicating important information about medicinal plants (Bennett, 2007; Leonti et al., 2002). In a region with historically high prevalence of infectious disease, the actuality that many plants used postpartum in SSA have anti-infectious and related activities supports their potential contributions to immediate and long-term health (Cordeiro et al., 2020). Many phytochemicals pass into breastmilk with sensory implications suggesting that *in utero* and postnatal exposure to bitter constituents offers an important learning pathway for child acceptance of various forms of medicinal plants, of lifelong significance in SSA (Sibeko et al., 2021).

Maternal ingestion of phytochemicals during the postpartum period has importance for immunological and other aspects of infant development as well as for maternal health and well-being (Sibeko et al., 2021). Table 4 summarizes the anti-infectious, anti-inflammatory, immunological, nervous system, galactagogue, and toxicological activities relevant to the postpartum period.

These species lack convincing demonstration of galactagogue activity (Cordeiro et al., 2020), but their anti-infectious, analgesic, and sedative activities offer immediate potential benefit to the mother. Although anti-inflammatory, antioxidant, immunological, and antimicrobial phytochemicals from African medicinal plants potentially mediate infant health and development, investigation of their presence in breastmilk and infant lumen and blood, as well as activity on infant microbiome, development, and behavior is required (Sibeko et al., 2021).

Contributions of maternally-ingested phytochemicals to development of the breastfeeding infant coincides with an apparent overlooked traditional comprehension of galactagogues in relation to milk quality - opposed to quantity as per how the concept is classically defined (Sibeko and Johns, 2021; Sibeko et al., 2021). Jendras et al. (2020) advance this notion in a survey among the BaKongo in Northern Angola that identified 33 species for “cleansing” mothers’ milk. Functional contribution of antimicrobial properties is central to their interpretation of this pattern. The (only) 21 additional URs we encountered (Appendix A) that identify plants used to “purify” or otherwise improve milk quality suggest, on one hand, that similar concepts are part of traditional perinatal knowledge in Central, Eastern and Western Africa, but perhaps more significantly that the recording and tabulation of this aspect of women’s knowledge has in the past lacked the nuance that becomes possible when research focuses specifically on breastfeeding or the perinatal period.

4.2.4. Newborn and infant health

Newborn and infant health covers a range of health conditions and medicinal plants. As summarized in Table 5, the largest portion of URs correspond to conditions of the gastrointestinal tract (colic, diarrhea, constipation, et cetera) (18.2%). Although information is typically recorded in a sparse manner, we assume infectious agents are relevant for a majority of this category. Together with respiratory disease (2.0%) and an array of specific infectious conditions (Other (12.2%), infectious categories represent 32.4% of the URs. Additionally, many dermatological reports (4.6%) reinforce the assumption that infectious agents are the target of at least a third of the medicinal plant applications related to newborn and infant health (also *cf.* fontanelles and umbilical healing). 17.7% of reports are explicitly related to fontanelles, either for facilitating closure of cranial sutures or for treating sunken or bulging fontanelles, conditions symptomatic of underlying dehydration or fever (possibly of infectious etiology (Kiesler and Ricer, 2003). Application of plants to facilitate healing of the navel or detachment of the umbilical cord was recorded at 8%. 19.5% of URs fall into the strengthening category. A large portion of these are specifically identified as tonics or described in general terms (16.9%), with a small number specifically designated as nutritional or promoting growth (2.5%). Cleaning the newborn or infant (typically bathing) and nervous and behavior concerns (*e.g.*, convulsions, crying) (3.9%), plus a number of miscellaneous conditions (9.2%), complete the categories.

As evidenced by Table 1D and Appendix A, individual plants generally lack specific association with any one of the above indications, with the most frequently reported plants summarized broadly for “infant care”. An exception is the use of plants to support healing of the umbilicus, with the family Crassulaceae standing out in Western, Eastern, and Central regions. For the most frequently reported species, *Bryophyllum pinnatum*, extensive *in vitro* and *in vivo* investigations support wound-healing and related antibacterial, analgesic, and anti-inflammatory activities (Fernandes et al., 2019). A smaller body of research reports similar activities for *Kalanchoe crenata* (Akinsulire et al., 2007; Dimo et al., 2006; Nguelefack et al., 2006).

Anti-infectious and/or anti-inflammatory activity has also been reported for all other plants in Table 1D: *Aframomum melegueta* (Table 5), *Annona senegalensis* (Quilez et al., 2018), *Bauhinia reticulata* (N’guessan et al., 2015), *Bidens pilosa* (Jayasundera et al., 2021), *Calotropis procera* (Parihar and Balekar, 2016), *Clausena anisata* (Appiah et al., 2017; Tankeo et al., 2015), *Ficus sur* (Cordeiro et al., 2020), *Harungana madagascariensis* (Happi et al., 2020), *Momordica charantia* (Jia et al., 2017), *Ocimum gratissimum* (Abiodun et al., 2011; Melo et al., 2019), *Piper umbellatum* (Arunachalam et al., 2020; Roersch, 2010), *Sarcocephalus latifolius* (Haudecoeur et al., 2018), and *Xylopia aethiopica* (Table 5).

Among the plants in Table 1D, experimental evidence supports immunomodulatory activity for *Bidens pilosa* (Jayasundera et al., 2021), *Calotropis procera* (Parihar and Balekar, 2016), and *Momordica charantia* (Jia et al., 2017), as well as analgesic and/or sedative activity for *Calotropis procera* (Parihar and Balekar, 2016), *Clausena anisata* (Appiah et al., 2017), *Ficus sur* (Cordeiro et al., 2020), and *Sarcocephalus latifolius* (Haudecoeur et al., 2018).

Among over-used taxa, Asteraceae and Crassulaceae stand out for infant use in contrast to being generally under-used in African medicinal families (Van Wyk, 2020).

4.3. Toxicity

Toxicity data related to Lactation and Postpartum Recovery (Table 4) provide an overall pattern suggesting most plants presented in Table 1C are probably safe as used (Cordeiro et al., 2020; Sibeko and Johns, 2021). Although potential benefit during the postnatal period appears to exceed risk, adequate studies generally are lacking. Cases that raise specific concerns and calls for further investigation include: *Aframomum melegueta, Cynanchum viminale, Ozoroa insignis, Tetrapleura tetraptera*, and *Xylopia aethiopica*.

Such deficiency of data is more problematic related to plant use during pregnancy, particularly the 1st trimester, or when administered directly to infants. Of prenatal plants (Table 1A), specific

Table 4
Anti-infective, immuno-inflammatory, anti-oxidant, antidepressant, galactagogic and safety-related activities for plants most-used postpartum in Sub-Saharan Africa.

Plant	Anti-microbial activity / Infectious diseases	Immuno-inflammatory and antioxidant effects	Other	Safety
Aframomum melegueta Grains of paradise, alligator pepper	Extracts with variable antibacterial activity (Amadi et al., 2016; Sokamte et al., 2018)	Anti-inflammatory activity of ethanolic extracts in rat paw edema model attributed to COX-2 and pro-inflammatory genes inhibition by [6]-paradol and shogaol. Strong antioxidant activity *in vitro* and *in vivo* attributed to phenolics (Amadi et al., 2016; Sokamte et al., 2018).	Extracts show analgesic activity in rats (Biobaku et al., 2021), anxiolytic and antidepressant activity in mouse model (Ojo et al., 2018). Prolactin reduction in rats suggests antilactogenic activity (Ibekwe, 2019).	Extended use shows hematological and histopathological evidence of potential toxicity (Biobaku et al., 2021).
Arachis hypogoea Groundnut, peanut (Cordeiro et al., 2020)	Significant activity against bacteria and viruses of seed skins and seeds attributed to flavonoids, stilbenes and phenolic acids. Prenylated stilbenoids significantly active against gastroenteritis-causing rotoavirus. Ethanolic extracts of shells are amoebicial.	Pro-inflammatory cytokines TNF-α, IL-6 and IL-1β and PGE2 reduced with iNOS, COX-2, MAPK and NF-kB inhibition in LPS-induced macrophage and other cellular models by seed skin and sprout attributed to stilbenes and proanthcyanidins. Strong antioxidant activity of seed skins and germinating seeds attributed to phenolic constituents.	Aqueous extracts of stem and leaves show sedative and anxiolytic activity in mice.	Recognized food ingredient. Potential allergen or source of mycotoxin contamination.
Brenandendron donianum (syn. *Vernonia conferta*)	Root showed inhibitory activity against filarial worm (loa–loa) and relatively low cytotoxicity (Toyang and Verpoorte, 2013). Leaves with antiplasmodial activity *in vivo* Orabueze et al., 2018).			
Carica papaya Papaya (Cordeiro et al., 2020)	Leaves, seeds and fruit peel active against bacteria and *Candida albicans*. Leaf has anti-viral activity with anti-dengue potential. Antimalarial activity of leaf extracts in mice attributed to alkaloids. Leaf inactive against typhoid. Athelminitic activity of seeds and latex attributed to alkaloids and cysteine proteinases, respectively.	Pro-inflammatory cytokines reduced. Th1, Th2 and T-reg modulation, reduced NF-kB, and iNOS and other immune effects. Antioxidant activity higher in seeds and fruits than leaves; reduction of intracellular reactive oxygen species in cellular models.	Pulp extract shows anxiolytic activity in mice.	Safe at normal doses, nontoxic in rats.
Cynanchum viminale (syn. *Sarcostemma viminale*)		Ethanolic extract induced TNF-α and other pro-inflammatory markers in murine macrophage model (Brestovac et al., 2015).		Leaf extracts overall safe at highest dose in rats but with uncertain subchronic kidney effects (Yahaya et al., 2015).
Elaeis guineensis Oil palm	Methanolic leaf extracts show broad spectrum antimicrobial activity; mannanoligosaccharides from kernel cake selectively promoted probiotic growth; ethanolic leaf extract active against *Plasmodium falciparum* (Agostini-Costa, 2018; Ajayi et al., 2016).	Leaf extract and tocotrienol-rich fractions from crude oil anti-inflammatory via immunomodulation; antioxidant activity of fruits and leaves attributed to phenolics and carotenes (Agostini-Costa, 2018).		Crude leaf extracts nontoxic to mice at highest doses Syahmi et al., 2010); oil isolates non-toxic (Agostini-Costa, 2018).
Euphorbia hirta Asthma plant (Cordeiro et al., 2020)	Variable antimicrobial activity against bacterial and fungal species. Antimalarial activity of leaf and plant extracts *in vitro*. Anthelmintic activity in *Onchocerca* and other nematode models.	Pro-inflammatory cytokines reduced, reduction in Th1 and increase in Th2 cytokines. NO production and iNOS expression reduced. Strong antioxidant activity in animal and *in vitro* models.	gastrointestinal motility (rats) and castor oil-induced diarrhea (mice) decrease attributed to flavonoids. sedative, anxiolytic and anti-pyretic activities of aqueous extracts observed in rodent models.	nontoxic in rats, possible cns depression and genotoxicity
Ficus sur Cape fig, broom cluster fig (Cordeiro et al., 2020)	Stem bark and leaves with variable antibacterial activity *in vitro*. Active *in vitro* against tuberculosis (bark, root) and *Entamoeba hystolytica*, but inactive against typhoid (leaf extracts) and malaria *in vitro* and *Trypanosoma brucei gambiense* in mice.	Anti-inflammatory activity of methanolic leaf extracts in carrageenan-induced rat paw edema. COX-2 inhibition high (bark) to moderate (root) for dichloromethane extracts. Strong antioxidant activity in bark and roots attributed to flavonoids and stilbenes.	Extracts of leaves and stem bark show analgesic and sedative activities in rodent models.	Leaf extracts nontoxic in acute, short-term and neonatal rats models; bark and root non-genotoxic.
Guiera senegalensis	Broad spectrum antimocrobial activity, antimalarial and	Antioxidant activity of leaf and gall extracts attributed to		Aqueous extracts administered orally or intraperitoneally

(*continued*)

Table 4 (*Continued*)

Plant	Anti-microbial activity / Infectious diseases	Immuno-inflammatory and antioxidant effects	Other	Safety
	antitrypanosamal activity *in vitro* and *in vivo* (Dirar and Devkota, 2021).	phenolics (Dirar et al., 2019; Sombie et al., 2011).	Sedative and analgesic activity in mice (Dirar and Devkota, 2021; Jigam et al., 2011).	nontoxic in rodents at highest doses, but some intramuscular toxicity (Dirar and Devkota, 2021).
Kigelia africana Sausage tree (Cordeiro et al., 2020)	Variable activity against bacteria and fungi *in vitro* attributed to iridoids and naphthoquinones. Weak antiviral activity. Antimalarial activity of stem and root barks *in vitro* attributed to iridoids and naphthoquinones.	Efficacy of stem bark and leaf extracts in carrageenan-induced rat paw edema assay and COX-1 and COX-2 inhibition attributed to verbascocide and verminoside; inhibition of iNOS and NO release in LPS-stimulated macrophage (verminoside) and NF-kB activation and TNF-α (verbascoside). Antioxidant activity *in vitro* of leaves, fruit, bark and roots attributed to flavonoids, verbascoside and other phenolics.	Leaf and root extracts show antidiarrheal activity in animal models. Analgesic activity of fruit, stem bark and flower extracts in mouse model. Lapachol and related naphthoquinones show anxiolytic and antidepressant activities in mouse models	Systematic safety data lacking. Extracts well-tolerated intraperitoneally and orally at lower doses with acute toxicity observed in highest doses.
Manihot esculenta Cassava (Cordeiro et al., 2020)	Leaf extracts show moderate broad spectrum antibacterial activity. Scopoletin from root skin antifungal. Anthelmintic activity of methanolic leaf extracts *in vitro* against *Trichostrongylus colubriformis* and other nematodes.	Anti-inflammatory activity of aqueous and ethanolic leaf extracts in carrageenan, and histamine-induced rat paw and xylene-induced ear edema tests. Phenolics in leaves and roots (less) responsible for antioxidant activity.	Antidiarrheal activity of ethanolic leaf extract in rat model. Yeast-induced pyrexia in rats inhibited by ethanolic leaf extract. Analgesic activity in rat models.	Leaf extracts nontoxic in acute and sub-chronic rat models. Stress-elevated cyanogenic glycosides in roots and leaves as staple foods responsible for konzo disease outbreaks.
Milicia excelsa Iroko, African teak (Cordeiro et al., 2020)	Bark contains sesquiterpenes and monoterpenes with known antibacterial and antifungal activity. Wood stilbenes with antiamoebic and variable antibacterial activity.	Acute, chronic, and topical anti-inflammatory activity in rodent models for methanolic bark extracts; LPS-induced NO inhibition in BV-2 microglial cells by moracin M. Limited antioxidant investigation: bark contains known antioxidant monoterpene linalool.	Antidiarrheal activity in rat model attributed to flavonoids and tannins. Stem bark extracts show sedative activity in mouse sleep models.	Stem, leaf and root extracts and fractions nontoxic at 5 g/kg in mice.
Musanga cecrepioides Corkwood, umbrella tree (Cordeiro et al., 2020)	Stem bark and leaf extracts moderately antibacterial. Antiprotozoan activity (stem bark) against *Trypanosma brucei* and *Leishmania infantum*; Stem bark and leaf active against tuberculosis *in vitro*.	Anti-inflammatory activity of ethanolic leaf extracts in carrageenan, serotonin and histamine-induced rat paw and xylene-induced ear edema tests.	Antidiarrheal activity of stem bark in mouse model. Leaf extracts with analgesic activity in mouse model.	Stem bark and leaf extracts fractions nontoxic at 3 g/kg in rats and mice, respectively.
Ozoroa insignis Tropical resin tree (Cordeiro et al., 2020)	Stem bark extracts with moderate activity against broad range of bacteria. Leaf and plant extracts with little antibacterial activity; inactive against *Candida albica* and in viral assays. Root bark and leaf extracts strongly active *in vitro* against tapeworm and *Schistosoma mansoni*. Antitrypanosomal activity of aerial parts *in vitro*.	Variable results from *in vitro* antioxidant assays of aerial parts (stems and leaves).		Ethanolic plants extracts toxic to mice above 1 g/kg
Pterocarpus angolensis African teak	Bark extracts with variable antimicrobial activity (Chipinga et al., 2018), and antiplasmodial *in vitro* (Zininga et al., 2017).	Antioxidant activity *in vitro* attributed to phenolics (Anokwuru et al., 2017; Santos et al. 2020).		
Ricinus communis Castor plant	Extensive antimicrobial (Ribeiro et al., 2016; Santos et al., 2018) activities.	Anti-inflammatory in animal (Ilavarasan et al., 2006; Lomash et al., 2010; Singh et al., 2013)] and cellular (Nemudzivhadi and Masoko, 2014) models. Antioxidant activity (Nemudzivhadi and Masoko, 2014; Ribeiro et al., 2016).	Root, leaves and seeds with analgesic, sedative and antinociceptive activity in rodent models (Abdul et al., 2018; Esfandyari et al., 2018) linked with sesquiterpenes (Farooq et al., 2018).	Leaves and roots nontoxic in mice and rats (Ilavarasan et al., 2011; Sadashiv, 2011).
Secamone afzelii	Methanolic extracts with variable antibacterial activity (Adu et al., 2019; Hoekou et al., 2015); weak antiplasmodial activity (Weniger et al., 2004).	Methanolic leaf extract with anti-inflammatory activity in carrageenan-induced chick paw edema; *in vitro* antioxidant activity correlates with phenolic content (Mensah et al., 2014).	Galactagogue study in rats: study design lacks validity (Adepo et al., 2017).	Methanolic extracts cytotoxic in brine shrimp assay (Lagnika et al., 2011).

(*continued*)

Table 4 (*Continued*)

Plant	Anti-microbial activity / Infectious diseases	Immuno-inflammatory and antioxidant effects	Other	Safety
Tetrapleura tetraptera	Fruit extracts with significant antibacterial activity; extracts of fruit and barks show anti-malarial activity *in vitro* and *in vivo* (Adesina et al., 2016).	Proinflammatory cytokines, IL-8 and IL-6, reduced through inhibition of NF-κB transcription; inhibition of COX-2 gene expression (Nwakiban et al., 2020). Aqueous fruit extracts reduced acute albumin-induced inflammation in rat hind paw edema model; fruit and bark extracts with significant antioxidant activity (Adesina et al., 2016).	Analgesic, anxiolytic and sedative activity in mice attributed to saponin aridanin (Adesina et al., 2016).	Aqueous stem bark extracts show no acute toxicity in mice, but evidence of sub-acute (29 days) liver toxicity in rats (Dongmo et al., 2019).
Vernonia amygdalina Bitter leaf	Variable antimicrobial activity in vitro; antimalarial and anti-leishmanial activity *in vitro* and *in vivo* (Toyang and Verpoorte, 2013).	Leaf extracts reduced LPS-induced expression in macrophages of COX-II, iNOS, pro-inflammatory factors, including NO, TNF-α, IL-1β, and IL-10, and inhibited MAPK and NF-κB expression (Wang et al., 2020). Immunomodulatory effects in rats include increase in CD4+, white blood cell, and total lymphocyte counts (Ezeonu et al., 2016).Variable antioxidant activity *in vitro* and *in vivo* (Toyang and Verpoorte, 2013).	Leaf extracts show antinociceptive activity in rodent models (Asante et al., 2019). Aqueous leaf extracts have galactagogue and oxytocic activity in guinea pigs (Ijeh et al., 2011).	Extracts nontoxic in rat studies; acute intraperitoneal toxicity in rabbit model reported as LD50 of 1122 mg/k (Toyang and Verpoorte, 2013).
Xylopia aethiopica African pepper, Ethiopian pepper	Extracts and essential oil show variable antimicrobial activity; xylopic acid and stem bark essential oil antimalarial *in vitro* and *in vivo* (Fetse et al., 2016).	Variable activity in reducing pro-inflammatory cytokines (Macedo et al., 2020; Nwakiban et al., 2020) modulation of inflammation in mice paw edema models attributed to xylopic acid (Osafo et al., 2018). Fruit and bark extracts antioxidant *in vitro* and *in vivo* (Fetse et al., 2016; Mohammed and Islam, 2017).	Analgesic, antidepressant and sedative activities of fruit extracts in rodent models attributed to xylopic acid (Biney et al., 2016; Woode et al., 2016).	Toxicity studies of extracts and essential oil inconclusive but further study needed (Fetse et al., 2016; Imo et al., 2021; Ekeanyanwu et al., 2020).

cautions arise for use during pregnancy for *Ageratum conyzoides* (Diallo et al., 2015), *Alchornea cordifolia* (Boniface et al., 2016), *Cissampelos mucrontata* (Lampiao et al., 2018), *Ocimum gratissimum* (Sripriya et al., 2011), *Ruta chalepensis* (Coimbra et al., 2020), and *Sarcocephalus latifolius* (Haudecoeur et al., 2018). For plants related to newborns and infants, cautionary data have been reported for *Aframomum melegueta* (Table 4), *Calotropis procera* (Kinda et al., 2019), *Harungana madagascariensis* (Happi et al., 2020), *Momordica charantia* (Omokhua-Uyi and Van Staden, 2020), and *Sarcocephalus latifolius* (Haudecoeur et al., 2018). Most data come from *in vitro* and/or acute, subacute, and sub-chronic studies with rodents. More extensive investigations are called for and, for plants that otherwise appear safe, need extension to gestational and neonatal models, as well as to humans. One case report documented toxicity in a 9-year old boy, apparently after *Alchornea cordifolia* therapy (Bunga et al., 2018).

Table 5
Newborn and infant health: frequency of use reports and percentage of total ($n = 1141$).

Indication	UR subtotal (%)	Total URs (%)
Infection related		370 (32.4)
Gastrointestinal	208 (18.2)	
Respiratory	23 (2.0)	
Other	139 (12.2)	
Strengthening		222 (19.5)
Tonic	193 (16.9)	
Nutrition / growth	29 (2.5)	
Fontanelles		202 (17.7)
Umbilical healing		80 (7.0)
Clean newborn or infant		66 (5.8)
Dermatological		52 (4.6)
Nervous system and behavior		44 (3.9)
Miscellaneous		105 (9.2)

Of the plants in the uterotonic category, specific cautions arise for *Jatropha curcas* (Cavalcante et al., 2020; Insanu et al., 2013), *Momordica charantia* (Omokhua-Uyi and Van Staden, 2020), and *Securidaca longipedunculata* (Moroole et al., 2019). Absence of acute toxicity suggests that many of the uterotonic plants are safe as used. However, the lack of fetal and infant data call for targeted research using neonatal and parturition models, and investigation of the plants in this category more generally.

4.4. Documentation of SSA medicinal plant knowledge

Increased recording of perinatal and other medicinal plant uses since 2005 reflects prioritization of traditional investigation coincident with expanding African scholarship and electronic publishing options. Although based on over a century of research grounded in the colonial era, records of new specific uses draw from community level studies from all subregions of SSA. New records of new genera and families are reported more slowly.

While a few iconic species have widespread utilization during the perinatal period (Table 1), in many instances selection appears to be at the level of genus and family. Generic-level selection in the perinatal period is consistent with observations that traditional pharmacopoeias tend to draw from widespread and species-rich taxa (Leonti et al., 2013).

In the case of Lactation and Postpartum, widely reported (across 3–4 subregions) species (*Euphorbia hirta, Ficus sur, Carica papaya, Milicia excelsa, Kigelia africana, Arachis hypogaea, Ozoroa reticulata*) do stand out more than genera. With the other categories, selection at the level of genus is common across subregions. In the Prenatal category, although 18 of the 21 most reported species (Table 1B) are widespread, genera with multiple species similarly employed are associated with the Amaranthaceae (*Amaranthus*), Asteraceae (eg. *Baccaroides, Solanecio*), Combretaceae (*Combretum*), Fabaceae (eg. *Albizia, Desmodium, Indigofera*), Moraceae (*Ficus*), Phyllanthaceae (*Phyllanthus*) and Vitaceae (*Cyphostemma, Rhoicissus*). Among uterotonics, four genera in the Fabaceae (*Albizia, Indigofera, Senna, Vachellia* (*Acacia sensu lato*)) and three Malvaceae (*Sida, Grewia, Triumfetta*) are each represented by multiple species, while individually *Bidens pilosa, Cleome gynandra, Musa* X *paradisiaca, Ricinus communis* and *Vernonia amygdalina* are also widely reported. For Newborn and Infant Health the place of *Bryophyllum pinnatum* and *Kalanchoe crenata* together at the top of the species list supports selection at the family level (Crassulaceae) (Table 2) for umbilical healing. *Bidens pilosa, Clausena anisata, Harungana madagascariensis*, and *Ocimum gratissimum* are widely used infant species (Table 1D), with genera selected across regions including *Aloe, Cymbopogon, Oxalis, Pterocarpus, Senna, Solanum, Syzygium*, and *Terminalia*.

4.5. Non-random selection

Non-random association at the level of family or genus indicates selection based on shared genetic traits. However, this does not differentiate a physiological or pharmacological rationale from culturally and cognitively mediated mechanisms such as doctrine of signatures, nor from ecological or historical factors (Savo et al., 2015; Weckerle et al., 2011). That use related to perinatal health extends over many families tends to reinforce the reality that many phytochemical pathways are widespread, or that different classes of phytochemicals can exhibit similar functional activities. Molecular phylogenic methods offer potential for deeper examination of SSA perinatal selection patterns, either by discerning functional domains within a family or generic level phylogenic tree of a predefined flora (Gras et al., 2021; Yessoufou et al., 2015), or mapping categories defined by ethnobotanical use against phylogenic trees constructed from taxa found in the dataset (Pedrosa et al., 2021). Promising trends involving medicinal plants have been demonstrated in several contexts. Phylogenic signals are often weak (Pedrosa et al., 2021) but demonstrate the importance of further methodological development and exploration of ethnobotanically-applicable best practices (Saslis-Lagoudakis, 2011, 2012). An exploration of the flora of Mt. Kilimanjaro found clusters of medicinal species within multiple domains scattered over the phylogenetic tree that the authors speculated could be “disease-specific” (Molina-Venegas et al., 2020). In a phylogenetic analysis at the genus level of the Cape flora of South Africa, commonly used medicinal plants categorized by indication (Yessoufou et al., 2015) were not clustered, although in one metric a significant effect was seen for facilitation of childbirth (but not abortion). In a study in Catalan-speaking territories, pregnancy, birth and puerperal disorders was one of three (of 15) medicinal groups producing a robust hot node (Gras et al., 2021).

4.6. Gender specific knowledge

Greater attention globally to the gender specific nature of traditional knowledge and to women’s particular expertise in relation to reproduction and children’s health is reflected in SSA by unprecedented publication of perinatal-focused publications during this time period. Although these are only 10% (67/639) of the total of sources for our data (primary studies reviewed (n = 392) and sources identified in compilations (n = 247)), alone they account for more than 30% of the URs we tabulated. Novel data and insights afforded by this focus on women’s knowledge in the perinatal period (*cf.* Jendras et al., 2020) supports the need for comparative research guided by hypothesis-guided assessment of knowledge gaps and attention to methodological best practices (Sibeko et al., 2021).

While some investigations are definitive in identifying women as conveyors of the information reported, much of the information tabulated (Appendix A) is only circumstantially attributable to women. This is particularly true of older reports or compiled data. Contemporary ethnobotanical studies usually characterize the population of informants in terms of age (range, mean) and gender, but often state number or relative portions of women and men, rather than disaggregating use reports specifically contributed by women. Comparative exploration of knowledge patterns of women and men (including spouses), or among women of different parity status and age directed at questions concerning knowledge transfer and behavioral determinants of child-rearing success (Cordeiro et al., 2020; Scelza and Hinde, 2019), are not possible with these data. Knowledge and roles of grandmothers and women elders (Dlisani and Bhat, 1999; Jendras et al., 2020) including TBAs, their participation during the perinatal period, and patterns and mode of inter-generational and community knowledge transfer, are issues raised sometimes in the literature we reviewed. Systematic investigations of these questions are called for.

4.7. Secular trends

Qualitative observation points to several notable species that only appear in the published record (Appendix A) recently. This could reflect either changes in the nature of research conducted or in actual patterns of use across the region. In the case of *Linum usitatissimum* and *Ruta chalepensis*, first appearing in 2003 and 2009 respectively, the fact all reports are Ethiopian likely relates to the upsurge of ethnobotanical research in a culturally and ecologically unique country that had been previously under-represented. More widespread species recently introduced to the perinatal record include *Allium sativum* (garlic) (2007), *Azadirachta indica* (2008), and *Mangifera indica* (2010). All records of *Cocos nucifera* as a galactagogue appear after 2009. With the exception of two early (1936, 1964) references on *Zingiber officinale* (ginger) as a galactagogue from Tanzania, all other references are from 2007 or later. That four of these species (*A. sativum, A. indica, R. chalepensis, Z. officinale*) overlap with the most widely reported species in Ahmed et al. (2018) reinforces secular trends, but may also reflect bias in current medicinal plant research towards studies coincident with access to healthcare facilities.

Adoption of well-known species across the region coincides with demographic and economic trends that reflect globalization of medicinal plant use, and presumably concomitant erosion of African traditional knowledge. The fact that garlic and ginger (the top 2 species recorded by Ahmed et al.) are the only plants in Table 1 for which clinical data is available to support safety during pregnancy, reflects a pattern where culturally mediated behaviors are mediated by global socioeconomic influences and access to scientific expertise.

4.8. Limitations

Although data analyses leading to Tables 1 and 2 weighs all URs tabulated in Appendix A equally, the extended time frame from which we tabulated perinatal knowledge diminishes data comparability in several regards. In the first instance are differences between compilations and primary studies. Methodological details provided in the latter usually allows for adequate understanding of the nature of data recorded. Newer studies more likely adhere to current best practices in providing fulsome details on informants (age, gender, ethnicity) and communities, as well as methods of data collection, although format and details of presentation is variable in quality and often open to interpretation. Taxonomic presentation, including collection of herbarium specimens, expertise of those responsible for identification, and/or taxonomic authority of the names given is many times deficient. We have not applied criteria ascertaining quality that could screen out data of lesser validity.

For older data, methods of collection, source community, and informant characteristics are often non-specific and non-verifiable. Seldom is it possible to validate herbarium specimens and species identification. Older publications and compilations may be citing the same sources which presents a challenge for dereplicating data. On the other hand, older references may consolidate data from more than one source, meaning that they do not fully represent the richness of knowledge across multiple communities or informants, or across time. Moreover, compilations are sometimes selective and not thorough in presenting all of the original reports they draw from. In other instances, they can be mutually contradictory or mispresent the original sources.

5. Conclusion

High prevalence of maternal health care outside of formal facilities and concurrent use of medicinal plants underlines the public health relevance of research in this area. Publication explosion of SSA medicinal plant use demonstrates that traditional plant knowledge remains extant and relevant to the physical and cultural well-being of African populations.

Ethnobotanical research in SSA is in an unprecedented phase of data accumulation related to traditional medicinal knowledge. Systematic review and secondary data-analysis offers insights into SSA perinatal plant use and helps identify directions for research targeted towards questions of broader import. In the first instance frequency tabulations and statistical patterns support the assessment that selection of medicinal plants is non-random. Rather, across SSA purposeful plant use that aligns with positive health outcomes is shared within a cultural context. A growing body of pharmacological data provides circumstantial evidence for the functional importance of traditional medicinal plant knowledge in achieving reproductive success. Within pluralistic African systems, documentation of traditional practices can contribute to complementary approaches and the mediation of potential conflicts with conventional healthcare.

Highlighting of key plant taxa can direct analytical investigations related to perinatal health with potential for applied use or to better understanding of present and past determinants of health and well-being. Secondary data analysis can offer new insights in conjunction with refinement and development of phylogenetic and other quantitative methodologies attuned to the unique characteristics of ethnobotanical data. The manner in which studies with perinatal-specific objectives have both expanded the field and provided novel insights (Jendras et al., 2020; Towns and van Andel, 2014, 2016) calls for expansion of approaches that generate comparative data. Refinement of quantitative and qualitative methodologies for eliciting detailed and in-depth knowledge concerning perinatal knowledge, beliefs, and practices are key for an integrative understanding of the congruence among sociocultural, ecological, evolutionary, molecular, behavioral, and health aspects of women's perinatal use of medicinal plants.

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Appendix A. Publication reports for plants used in Sub-Saharan Africa during the perinatal period - available as a Supplementary file.

Appendix B. Bibliography of plants used in Sub-Saharan Africa during the perinatal period - available as a Supplementary file.

Appendix C. Results of linear regression analysis, with the total number of African species and African medicinal species for each family. Families are ranked by studentized residual values - available as a Supplementary file.

Appendix D. Results of negative binomial analysis, with the total number of African species and African medicinal species for each family. Families are ranked by studentized deviance residual values - available as a Supplementary file.

Appendix E. Overused and Underused plant families from Bayesian and IDM analyses for each of the perinatal categories - available as a Supplementary file.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.sajb.2023.01.007.

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