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Constructing maternal morbidity – towards a standard tool to measure and monitor maternal health beyond mortality

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Abstract

Background: Maternal morbidity is a complex entity and its presentation and severity are on a spectrum. This paper describes the conceptualization and development of a definition for maternal morbidity, and the framework for its measurement: the maternal morbidity matrix, which is the foundation for measuring maternal morbidity, thus, the assessment tool.

Discussion: We define maternal morbidity and associated disability as *"any health condition attributed to and/or complicating pregnancy and childbirth that has a negative impact on the woman's wellbeing and/or functioning."* A matrix of 121 conditions was generated through expert meetings, review of the International Classification of Diseases and related health problems (ICD-10), literature reviews, applying the definition of maternal morbidity and a cut-off of >0.1 % prevalence. This matrix has three dimensions: identified morbidity category, reported functioning impact and maternal history. The identification criteria for morbidity include 58 symptoms, 29 signs, 44 investigations and 35 management strategies; these criteria are aimed at recognizing the medical condition, or the functional impact/disability component that will capture the negative impact experienced by the woman.

Summary: The maternal morbidity matrix is a practical framework for assessing maternal morbidity beyond near-miss. In light of the emerging attention to Universal Health Coverage (UHC) as part of the post-2015 Sustainable Development Goals (SDGs) planning, a definition and standard identification criteria are essential to measuring its extent and impact.

Keywords: Maternal morbidity, Definition, Measurement, Sustainable Development Goals (SDGs)

Background

Improving maternal health and reducing related mortality have been key concerns of the international community as one of the eight Millennium Development Goals (MDG 5) [1]. However, maternal mortality accounts for only a small fraction of the overall burden of poor maternal health. Maternal morbidity – the health problems borne by women during pregnancy, childbirth and the postpartum period contribute to this burden. Yet, the true extent of maternal morbidity is unknown. It has been suggested that for each maternal death, 20 or 30 women suffer from morbidity; however, these calculations are not based on standard, well documented, and transparent methodologies [2, 3]. Overall, three major issues have limited valid, routine, and comparable measurements of maternal morbidity, the lack of a common definition and identification criteria, standardized assessment tools especially at primary health care level, and common indicators to measure morbidity [2]. Developing measurement criteria for the burden of pregnancy and post-partum related morbidity is crucial to the ongoing elaboration of the post-2015 Sustainable Development Goals (SDGs) in light of required attention to morbidity as maternal deaths have dropped significantly over the past two decades [4].

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In 2011, the World Health Organization (WHO) developed a common definition and identification criteria for very severe cases of maternal morbidity (maternal near-miss) allowing its routine measurement and monitoring, especially as a tool for assessment of the quality of care women with severe morbidity receive [5]. Such definition and criteria do not exist for less-severe cases along the continuum of maternal ill health. It is necessary to arrive at a common definition and to establish clear criteria for accurate and routine measurement of maternal morbidity in order to inform policy decisions, resource allocation and ultimately to launch an appropriate programmatic response that will also help in reducing maternal deaths, and long-term suffering and disability. This is particularly essential at the community and primary care levels, where most of the burden of maternal morbidity is believed to be reported [6, 7], yet instruments to quantify and measure it are currently lacking [2].

To fulfill the need to measure and respond to the full burden of maternal morbidity, WHO initiated a project, funded by the Bill and Melinda Gates Foundation, to improve the scientific basis for defining, measuring and monitoring maternal morbidity. This project aims to construct a definition and develop identification criteria for maternal morbidity, estimate the burden of individual causes or determining factors of maternal morbidity based on existing evidence, develop and test an assessment tool for measuring maternal morbidity in low- and middle-income countries, and develop indicators for maternal morbidity.

The project is led and carried out by a technical working group, the Maternal Morbidity Working Group (MMWG), composed of obstetricians, physicians, midwives, epidemiologists, medical anthropologists, public health professionals and patient advocates from high-, middle- and low-income countries [2]. The WHO MMWG was initially convened in April 2012. Participants were invited to join the working group based upon their known technical expertise in quantitative and qualitative maternal health research, maternal health programs, contributions to other related research initiatives or membership on WHO technical advisory groups or with potential links to this work, consumer perspective, and to ensure regional and gender balance. Where this paper reports decisions by the MMWG, these were made by consensus discussions during five WG meetings (April and August 2012, February 2013, February and October 2014) as well as interim electronic communication.

Since 2012, the MMWG has elaborated on maternal morbidity from different perspectives, and on the basis of existing evidence has agreed on a common framework for maternal morbidity. This body of work is intended to complement the maternal near-miss morbidity concept, whereby together they specify the full continuum of maternal morbidity [2]. This work will be incorporated in the 11th revision of the key standards for health conditions - the International Statistical Classification of Diseases and related health problems (ICD), further enhancing the sustainability of the outputs [8]. While doing so, publishing the development process to ensure transparency and encouraging further collaboration from researchers, clinicians, and other stakeholders have been key to the work of the MMWG.

The objective of this paper is to describe this concept, and the framework, for identifying and measuring "non-severe" maternal morbidity, and the maternal morbidity matrix (see Figs. 1 2, 3 and 4) which informed the development of a "morbidity" tool, which will be pilot tested for usability, feasibility, and fit for purpose (Please see Table 1 for an outline of the tool's components). The "morbidity" tool is conceptualized to measure maternal morbidity in primary health care settings which have high levels of service demand [9]. Nonetheless, improved access is not enough, health services must also be of good quality [10]. Measuring morbidity can serve as an indicator of the quality of obstetric care [11, 12]. Ideally the long-term outputs of this project are to establish routine data collection on maternal morbidity to inform service provision at facility-level.

The MMWG deliberated the development of a community (non-health care setting) level tool to capture women who do not have regular access to medical services; however, given the time and resource constraints as well as consideration of prior research which found that women's recall of complications has low specificity and would necessitate observation by a trained health or community worker [13, 14] the Group chose to focus its efforts on the primary facility/lowest facility level point-of-care. We discuss the development of the concept, the components of the matrix and the theoretical and methodological underpinnings for each.

Discussion

Concept of maternal morbidity: rationale

A standard definition for maternal morbidity does not exist nor does the literature report maternal morbidity systematically in a commonly agreed upon approach [3]. On the basis of the background scoping exercise [3], and building upon the WHO definition of health [15] and maternal mortality [16], the MMWG, by consensus, agreed on the definition for maternal morbidity and associated disability as "*any health condition attributed to and/or complicating pregnancy and childbirth that has a*

	Symptom	Sign	Investigations	Management
DIRECT MATERNAL MORBIDITY				
Delivery/Termination				
Ectopic Pregnancy Unsafe Induced Septic Abortion Retained Products of Conception Gestational Trophoblastic Disease Obstructed Labour	abdominal/pelvic pain vaginal bleeding fever labour > 12 hours	changes in heart rate changes in blood pressure fever abnormal pelvic exam products of conception on pelvic exam	beta hcg pelvic/transvaginal ultrasound	methotrexate surgery antibiotics chemotherapy
Hypertensive Disorders of Pregnancy				
Hypertensive Disorders (Chronic hypertension, Gestational hypertension, Pre-eclampsia, HELLP, Eclampsia)	headache visual disturbance chest pain nausea and vomiting abdominal pain seizures	changes in blood pressure (hypertension) abnormal cardiac exam abnormal fundoscopy exam abnormal respiratory exam abnormal abdominal exam	uric acid creatinine urine analysis complete blood count blood smear liver enzymes CT scan chest X ray urine protein to creatinine ratio	antihypertensives magnesium sulphate diuretics antenatal corticosteroids blood transfusion
Obstetric Haemorrhage				
Accreta/Increta/Percreta Placenta (Morbidly adherent placenta) Placenta Previa Placental Abruption Postpartum Haemorrhage	abdominal pain back pain vaginal bleeding uterine contractions	changes in heart rate changes in blood pressure abnormal abdominal exam	complete blood count coagulation studies pelvic/transvaginal ultrasound	blood transfusion fluids uterotonics anti-shock garments surgical management
Pregnancy related Infection				
Mastitis/Breast Abscess Chorioamnionitis Puerperal Sepsis UTI/Pyelonephritis Tetanus	fever diaphoresis breast redness/tenderness/mass vaginal discharge abnormal urination lock jaw stiff neck rigidity muscle spasms	fever changes in blood pressure (hypotension, hypertension) changes in heart rate (tachycardia) breast redness, firmness and pain abnormal abdominal exam (abdominal/uterine/suprapubic tenderness)	blood cultures urine analysis and culture complete blood count breast ultrasound	fluids antibiotics benzodiazepines magnesium sulphate
Other Obstetric Complications				
Thrombotic Deep Vein Thrombosis Thrombophlebitis Septic Ovarian/Pelvic Vein Thrombophlebitis **Gastrointestinal** Nausea and Vomiting of Pregnancy Cholestasis of Pregnancy **Cardiovascular** Peripartum Cardiomyopathy Mirror Syndrome **Endocrine** Diabetes Mellitus (Gestational Diabetes) Postpartum Thyroiditis **Other** Intentional Self Harm	unilateral leg swelling calf tenderness fever abdominal pain nausea and vomiting pruritus changes in breathing oedema/anasarca decreased exercise tolerance/fatigue headache visual disturbance chest pain abnormal urination polydipsia tremor palpitations anxiety/irritability changes in weight suicidal ideation	fever changes in heart rate changes in respiration decreased oxygen saturation abnormal volume exam abnormal cardiac exam abnormal respiratory exam abnormal abdominal exam abnormal fundoscopy exam abnormal thyroid exam tremor unilateral leg swelling calf tenderness oedema/anasarca evidence of self-harm	complete blood count blood smear liver enzymes uric acid creatinine urine analysis urine protein to creatinine ratio chest X ray CT scan electrolytes echocardiogram thyroid studies fasting blood glucose HbA1c oral glucose tolerance test pelvic/transvaginal ultrasound doppler ultrasound of legs	antibiotics anticoagulation antiemetics antihypertensives diuretics insulin thyroid medications fluids
Unanticipated Complications				
Complications related to Anaesthesia Aspiration Pneumonitis Cerebral Anoxia **Complications of Management** *Spontaneous Vaginal Delivery* Perineal Tear (3rd or 4th degree) *Episiotomy* Episiotomy infection *Instrumental Delivery* Vaginal wall/perineal laceration Urethral tear/damage Vulval Haematoma *Caesarean Section* Uterine perforation Postpartum Inversion of Uterus Caesarean Section Wound Infection Post-operative ileus/bowel obstruction *Other* Ovarian hyperstimulation syndrome Nosocomial or hospital acquired infection (UTI, C diff, pneumonia)	changes in weight fever altered mental status seizures changes in breathing cough abdominal discomfort, pain and/or distension nausea and vomiting changes in bowel habits abnormal urination perineal pain/rectal pressure dyspareunia vaginal bleeding	fever changes in blood pressure changes in heart rate changes in respiration decreased oxygen saturation abnormal respiratory exam abnormal neurologic exam abnormal abdominal exam caesarean wound redness and/or discharge abnormal pelvic exam	complete blood count electrolytes creatinine coagulation studies ECG chest x-ray CT scan vaginal swabs	surgery fluids blood transfusion antibiotics antivenom

Fig. 1 Maternal morbidity matrix, Dimension 1: SYMPTOM, SIGN, INVESTIGATIONS & MANAGEMENT (Direct Maternal Morbidity)

negative impact on the woman's wellbeing and/or functioning." Heretofore, the term 'maternal morbidity' refers specifically to this definition of the concept. This broad definition recognizes the impact that morbidity may have on different dimensions of health, beyond physical health and seeks to encompass the totality of a woman's

	Symptom	Sign	Investigations	Management
INDIRECT MATERNAL MORBIDITY				
* *See list below*	fever chills diaphoresis/night sweats fatigue changes in weight headache visual disturbance cough changes in breathing chest pain palpitations light headedness cough jaundice change in appetite nausea and vomiting abdominal pain changes in bowel habits abnormal urination vaginal bleeding vaginal discharge anxiety irritability guilt changes in mood lack of interest difficulty concentrating hallucinations delusions impulsiveness change in eating habits excessive exercise compulsive behaviour suicidal ideation unilateral leg swelling and/or redness oedema/anasarca leg pain back pain joint pain skin rash/lesion neurological symptoms	changes in blood pressure fever changes in heart rate changes in respiration abnormal oxygen saturation bruises pallor abnormal fundoscopy abnormal mental status lymphadenopathy thrush (oral) abnormal thyroid exam abnormal cardiac exam abnormal respiratory exam abnormal abdominal exam abnormal neurological exam abnormal rectal exam abnormal pelvic exam skin rash/lesion abnormal musculoskeletal exam	complete blood count blood smear thick and thin smear for malaria haemoglobin electrophoresis fasting blood glucose HbA1c oral glucose tolerance test electrolytes creatinine urine analysis and urine protein: creatinine ratio chlamydia/gonorrhea PCR/ cultures viral PCR/ culture vaginal swab influenza swab hepatitis serology AFB stain and culture stool culture iron studies vitamin B12 level thyroid studies PTH level calcium ECG echocardiogram pulmonary function tests overnight oximetry skin biopsy bone marrow biopsy CT scan thoracentesis paracentesis	antibiotics antihypertensives insulin oral hypoglycemics anti retrovirals anti-malaria drugs TB medications anti virals anti fungals vitamin and mineral supplementation thyroid medications anti-psychotics anti-depressants diuretics other cardiac medications [beta blockers, ace inhibitors] steroids immunosuppressants chemotherapy radiation surgery
CO-INCIDENTAL				
External injury in pregnancy Motor Vehicle Accident (Transport accidents) Accidental exposure to smoke, fire, flames Accidental poisoning and exposure to noxious substance Accidental drowning and submersion Contact with venomous animals and plants Exposure to force of nature **Trauma in pregnancy** Falls Intimate Partner Violence Rape	history of external injury and/or trauma bleeding pain difficulty with mobility changes in breathing altered mental status seizures vaginal bleeding dyspareunia	changes in blood pressure hypothermia decreased oxygen saturation fractures burns bruises abnormal respiratory exam abnormal neurologic exam abnormal musculoskeletal exam	complete blood count electrolytes creatinine coagulation studies ECG chest x-ray CT scan vaginal swabs	surgery fluids blood transfusion antibiotics antivenom

***INDIRECT MATERNAL MORBIDITY- CONDITIONS**

Pre-existing Hypertension
Pre-exiting Diabetes Mellitus

Maternal infectious and parasitic diseases classified elsewhere but complicating pregnancy, childbirth and the puerperium
HIV/AIDS
Tuberculosis Mycobacterium
Malaria

Sexually Transmitted Infections
Chlamydia
Anogenital warts
Herpes Simplex
Syphilis

Other
Candidiasis
Influenza
Pneumonia
Infectious Hepatitis (A, B, C, E)
Varicella Zoster
Cholera

Other Maternal Diseases Classifiable Elsewhere but Complicating Pregnancy, Childbirth and the Puerperium
Acquired Anemia
Anemia due to vitamin B12 and/or folate deficiency
Iron Deficiency Anemia

Hereditary Anemia
Sickle Cell Anemia
Thalassemia

Other diseases in the blood and blood forming organs and certain disorders involving the immune mechanism complicating pregnancy, childbirth and the puerperium
Idiopathic Immune Thrombocytopenia (ITP)

Endocrine, nutritional and metabolic diseases complicating pregnancy, childbirth and the puerperium
Hyperparathyroidism

Thyroid disorders
Hyperthyroidism
Hypothyroidism

Mental disorders and diseases of the nervous system complicating pregnancy, childbirth and the puerperium
Anxiety Disorders
Adjustment Disorder
Anxiety Disorder
Panic Disorder
Post-traumatic Stress Disorder
Tocophobia (specific isolated phobias)

Mood Disorders
Bipolar Disorder
Major Depressive Disorder
Postpartum Blues
Postpartum Depression
Psychosis
Puerperal Psychosis
Schizophrenia

Diseases of the circulatory system complicating pregnancy, childbirth and the puerperium
Acquired and Congenital Structural Heart Disease (including valvular heart disease)
Aortic Dissection
Arrhythmia
Cardiomyopathy (dilated and restrictive)

Diseases of the respiratory system complicating pregnancy, childbirth and the puerperium
Asthma
Obstructive Sleep Apnea
Pulmonary Embolism

Diseases of the digestive system complicating pregnancy, childbirth and the puerperium
Anal Fissure
Hemorrhoids
Cholecystitis/cholylethiasis
Gastrointestinal Esophageal Reflux Disease (GERD)
Inflammatory Bowel Disease

Diseases of the Genitourinary System
Acute and Chronic Kidney Disease
Incontinence (urge, stress)
Uterine/Uterovaginal Prolapse (including cystocele)
Recto-vaginal fistula
Vesico-vaginal fistula

Diseases of the skin and subcutaneous tissue complicating pregnancy, childbirth and the puerperium
Pregnancy Specific Dermatoses
Eczema (Atopic dermatitis)
Prurigo of Pregnancy (Diseases of the skin and subcutaneous tissue complicating pregnancy, childbirth and the puerperium)
Pruritic Urticarial Papules and Plaques of Pregnancy (PUPP) or Polymorphic Eruption of Pregnancy (PEP) Linea nigra

Dermatoses aggravated by pregnancy
Acne
Psoriasis

Other specified diseases and conditions complicating pregnancy, childbirth and the puerperium
Diseases of the Nervous System
Bell's Palsy
Carpal Tunnel
Migraine
Multiple Sclerosis
Restless Leg Syndrome
Seizure disorder (excluding eclampsia)

Diseases of the Muskoskeletal System and Connective Tissue
Inflammatory arthritis
Ankylosing spondylitis
Rheumatoid Arthritis
Systemic Lupus Erythematosus (SLE)
Non-inflammatory arthritis
Back pain

Oncology
Cervical Dysplasia/Neoplasia
Lymphoma
Leukemia
Melanoma

Nutritional
Anorexia Nervosa
Bulimia Nervosa

Fig. 2 Maternal morbidity matrix, Dimension 1: SYMPTOM, SIGN, INVESTIGATIONS & MANAGEMENT (Indirect Maternal Morbidity)

Understanding	Watching (d110)
	Listening (d115)
	Learning (d130-d155)
	Focusing attention (d160)
	Reading (d166)
	Writing (d170)
	Calculating (d172)
	Solving problems (d175)
	Other specified
Communication	Communicating with others (d310 d315 d320 d325)
	Speaking (d330)
	Starting a conversation (d3500)
	Sustaining a conversation (d3501)
Mobility	Standing (d4104)
	Bending (d4105)
	Maintaining a body position (d4154)
	Transferring oneself (d420)
	Lifting and carrying objects (d430)
	Fine hand use (d440)
	Hand and arm use (d445)
	Walking short distances (d4500)
	Walking long distances (d4501)
	Vigorous activities (d455 d4303)
	Moving around within home (d4600)
	Moving around outside the home and other buildings (d4602)
	Using transportation (d470)
	Driving (d475)
Self-Care	Washing oneself (d510)
	Caring for body parts (d520)
	Urination (d5300)
	Defecation (d5301)
	Dressing (d540)
	Eating (d550)
	Drinking (d560)
	Managing one's health (needs, assistance or oversight) (d570)

Interpersonal Relations	Making friends (d7200 d7500)
	Engaging with other people (d740 d750)
	Maintaining family relationships (d760)
	Dealing with strangers (d730)
	Engaging in sexual relationships (d7702)
Life Activities Household	Shopping (d620)
	Cooking /preparing meals (d630)
	Doing housework (d640)
	Looking after/helping others
School	Attending school (d820)
	Learning a job (vocational training, apprenticeship) (d825)
	Going to university (d830)
Work and economic life	Engaging in paid work (d850)
	Seeking employment (d8450)
	Performing job related tasks (d8451)
	Handling money (d860)
Life management	Undertaking a single task (d210)
	Undertaking multiple tasks (d220)
	Carrying out daily routine (d230)
	Handling stress and psychological demands (d240)
Social Participation	Taking part in social life (d910)
	Sports (d9201)
	Travel (d920)
	Visiting friends (d9205)
	Human rights (e.g. self-determination, equal opportunities) (d940)
	Political life and citizenship (e.g. voting) (d950)
Children and Youth	Learning to read (d140)
	Learning to write (d145)
	Learning to calculate (d150)
	Communicating with others (d310 d315 d320 d325)
	Speaking (d335)
	Attending school (d8201)
	Taking exams (d8202)
	Playing with others (d880 d9200)

Fig. 3 Maternal morbidity matrix, Dimension 2: Functional Impact - International Classification for Functioning and Disability (ICF) codes

sense of wellbeing. Terminology used in this manuscript can be found in Table 2 below.

Based on this definition and with the goal of developing identification criteria to be embedded within a measurement tool for maternal morbidity, we initially focused on formulating and populating a matrix of conditions, not limited by the obstetrical and gynecological perspective. A number of issues were identified by the MMWG to inform the basic premises of the matrix, which members deemed necessary to include or at least consider for inclusion: 1) obstetric morbidities, 2) previous/co-existing conditions, 3) mental conditions, 4) intervention related morbidities, 5) trauma (i.e. domestic violence), and 6) cultural practices (i.e. female genital mutilation). In order to identify cases of maternal morbidity according to the agreed upon definition and to strike a balance between feasibility and utility in identification of maternal morbidity cases, we adopted a set of guiding principles to proceed with this work:

1) identification and measurement of the selected maternal conditions should be pragmatic, action oriented, evidence-based, feasible and applicable to different settings, with regional and international acceptance;
2) maternal morbidity should not be viewed as consisting only of the conditions themselves, but also their consequences; and
3) morbid conditions should be prioritized on the basis of their frequency and impact. In addition, we may focus on under- researched and neglected areas.

Balancing the tension between goals of being comprehensive and complete with usability and feasibility proved to be a challenge considering issues such as regional differences in disease incidence and prevalence, the spectrum of maternal morbidity, its occurrence, severity, duration, impact and how a morbidity affects the woman's well-being. To focus on *"what to measure"*, we considered the role of prevalence and impact, while recognizing the need to better understand under-researched or neglected areas and the need to define what is intended by the qualifiers of "attributed to" or "complicating". On *"how to measure"* maternal morbidity, we envisioned the development of a core module applicable to primary care settings. In either instance, the condition should be associated with a negative maternal outcome. We specified that the particular areas of interest would be the complications and/or manifestations of these conditions either during pregnancy or postpartum.

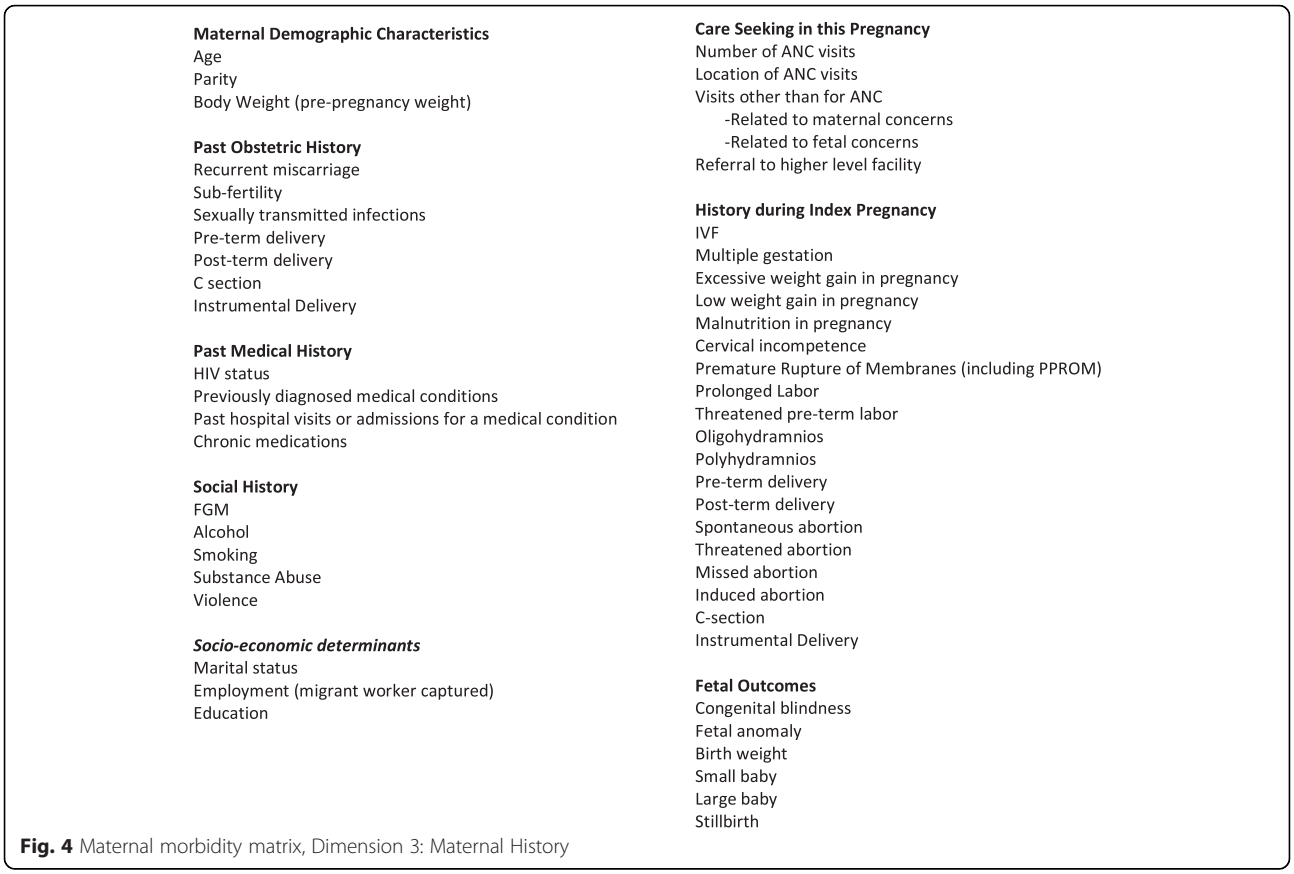

Fig. 4 Maternal morbidity matrix, Dimension 3: Maternal History

Maternal morbidity matrix: foundations of a measurement tool

To devise identification criteria we considered categorization of different markers anatomically or by system, as was done in the development of maternal near-miss concept. However, given the particularities of less-severe pregnancy related complications, a more holistic approach was favored. Unlike maternal near-miss events, which have by definition very specific clinical, laboratory and management markers, it was understood that such markers might not be sufficient enough to identify maternal morbidity [5, 11]. As such, the maternal morbidity matrix consists of three dimensions (Figs. 1 2, 3 and 4).

Table 1 Maternal morbidity draft tool components

Section 1: Personal history	Social and demographic information
	Obstetric history (focusing on current/ most recent pregnancy)
	Sexual Health
	Risk-factors/environment
Section 2: Symptoms	Disability and functioning –WHO Disability Assessment Schedule 2.0 (12-item version)
	General symptoms
	Mental health –Generalized Anxiety Disorders-7 –Personal Health Questionnaire –9
Section 3: Signs	General physical exam
	Laboratory tests and results

Similar to the near-miss criteria, we sought to develop a set of locally relevant criteria which allow for comparisons between different settings, regions and countries. Therefore, the *first dimension* consists of the symptoms, signs, investigations and management strategies. Unlike near-miss, symptoms are included in the identification criteria of maternal morbidity, with the anticipation that they would correlate strongly with the associated disability (e.g. fatigue, shortness of breath) and thus, may be the primary reason for women to seek care. Signs are findings on physical examination and are similar to the clinical criteria of the near-miss criteria. The identification criteria also include investigations, which are broader in scope than the lab markers for the near-miss criteria, and are comprised

Table 2 Definitions

Term	Definition
Maternal Death	The death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and the site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes [17]
Maternal Near-Miss	A woman who nearly died but survived a complication a complication that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy [11]. Signs of organ dysfunction that follow life-threatening conditions are used to identify maternal near-misses and a set of near-miss indicators enables assessments of the quality of care provided to pregnant women [5].
Maternal morbidity and associated disability	Any health condition attributed to and/or complicating pregnancy and childbirth that has a negative impact on woman's wellbeing and/or functioning.
Functioning	Is an umbrella term for body functions, structures, activities and participation. It denotes the negative aspects of the interaction between an individual (with a health condition) and that individual's contextual factors (environmental and personal factors) [29].
Disability	Is an umbrella term for impairments, activity limitations and participation restrictions. It denotes the negative aspects of the interaction between an individual (with a health condition) and that individual's contextual factors (environmental and personal factors) [29].

of laboratory tests, imaging studies and diagnostic tests such as biopsies. Management strategies include treatment options like medications, surgical procedures and radiation.

Initially, the Group aimed to make the matrix as comprehensive as possible, representing both developing and developed country settings. Informed by the WHO scoping exercise on maternal morbidity [3], reviews of published literature, relevant textbooks and the WHO Application of ICD-10 to deaths during pregnancy, childbirth and the puerperium: ICD-Maternal Mortality (ICD-MM) [17], a set of conditions were selected. We considered conditions that may occur in women of reproductive age including those specific to pregnancy and postpartum. A matrix was developed, including each of these conditions and their relevant symptoms, signs, investigations and management strategies. The first version included 301 conditions, originally cross-referenced with 109 symptoms, 106 signs, 121 clinical tests and 91 management strategies [2]. At this point, the MMWG recognized the existing health care structures in low- and middle-income countries (LMICs) to balance aspirational versus pragmatic approaches. Therefore, to further consolidate the matrix, the Group developed and agreed up the following criteria:

1) conditions associated with a negative maternal outcome that are either exclusive to pregnancy, childbirth, and the postpartum state, with an estimated occurrence of >0.1 % in pregnancy; or
2) conditions that are not exclusive to pregnancy, childbirth, and postpartum but which occur more frequently during pregnancy (i.e. pregnancy is a risk factor for the disease).

The cut-off of 0.1 % for occurrence (prevalence or incidence) was deemed to be a reasonable cut-off that distinguished between very rare diseases and diseases that are more common and was informed by current estimates of disease conditions in the published literature. When evidence was unavailable, the group used a consensus mechanism based on expert opinion. Additionally, to account for regional differences in prevalence of certain conditions, the Group intends for the tool, based on the matrix, to be revised for regional implementation.

Moreover, to frame the matrix we used the precedent of ICD-MM, a special adaption of the ICD-10 intended to improve the classification of maternal mortality and morbidity [11, 17]. We grouped the domains in line with the ICD-MM, such as pregnancies with abortive outcome, obstetric hemorrhage or non-obstetric complications, with the intent of showing how data at different levels of detail may be aggregated together and to ensure continuity between the spectrum of morbidity through mortality [17]. Additionally, though it is beyond the scope of this work to revisit the definition of "direct" and "indirect" maternal mortality (and by extension, morbidity); the work of this group in reviewing the conditions aligned to each category has been informing the discussion on whether the distinction between "direct" and "indirect" remain necessary or useful. As a result of the abovementioned process, the next version of the matrix includes 121 conditions cross-referenced with all identified criteria based on the ICD-MM groupings and generated 58 symptoms, 29 signs, 44 investigations and 35 management strategies. Conditions consistent with severe maternal morbidity as manifestations of maternal near-miss were not included in this consolidated matrix as they are already identified by the maternal near-miss tool [11].

A *second dimension* is the functional impact and disability assessing the loss of physical, psychological, cognitive, social and economic functions. Key concepts related to functioning and disability as conceptualized and defined in the International Classification of

Functioning, Disability and Health (ICF) are incorporated [11] thru the existing, validated tool, WHO Disability Assessment Schedule 2.0 (WHODAS 2.0) [18]. This tool covers 6 domains in line with ICF (cognition, mobility, self-care, getting along, life activities and participation) and produces standardized disability levels and profiles using a short, simple and easy to administer questionnaire [18]. In addition, preliminary findings from a systematic review on maternal morbidity and quality of life, currently in progress, will be used to refine our assessment tool to be more centered on maternal health to gauge women's experiences.

The *third dimension* is the maternal history focusing on social and health related characteristics, which might help identify the maternal morbidity as well as influence the risk and severity of the morbidity. Some examples include socio-economic determinants, pre-existing conditions, care seeking during the pregnancy, etc. Incorporating maternal demographic characteristics, past obstetric history, history during index pregnancy and fetal outcome allows full elaboration of the "woman as a whole". Inclusion of fetal measures in the index pregnancy appraises linkages between maternal morbidity and fetal outcomes, attesting to the irrefutable mother-baby dyad.

Conclusions

Time is now: implications and next steps

This body of work elaborates the first standard global definition and classification of maternal morbidity. The epidemiology of pregnancy and childbirth reflects changing demographic patterns; the latest global estimates on causes of maternal deaths demonstrate the increased role of indirect conditions in causing maternal deaths [19]. Moreover, as described in the "obstetric transition model", with declining maternal deaths, the proportion of individuals with morbidities can only be expected to rise [20]. Beyond documenting known contributors to this changing epidemiology, e.g. the increased age at which women become pregnant [21] and co-morbidities such as obesity [22], this framework puts the focus on the women and incorporates the concepts related to disability and functioning.

Based on this concept and framework, we are in the process of developing and testing a modular set of maternal morbidity assessment tools in three country settings. This tool will have different modules depending on the time of data collection (antenatal and postnatal). The assessment tools were designed based on the matrix by thorough iterations and expert review. Whenever possible, previously validated tools and scales were employed and adapted. For example, established sexual dysfunction and mental health scales are employed as part of the 1st dimension, the WHODAS 12-item version as part of the 2nd dimension and substance abuse and intimate partner violence scales as part of the 3rd dimension [18, 23]. The results of pilot testing will direct further refinement and development of the maternal morbidity tool to ascertain the potential need for regional or country level modifications and to determine its utility in identifying morbidities and issues related to implementation of the tool. Given the paucity of data on disability from LMICs and poorer resourced areas, the interpretation of these pilots will be critical. In the future, this framework can inform a probabilistic algorithm like the Interpreting Severe Acute Maternal Morbidity (InterSAMM) to identify morbidity, which was in turn modeled after the Interpreting Verbal Autopsy - 4 (InterVA-4) to identify cause of death [24–26].

By identifying a case of maternal morbidity, either via an identified morbidity category and/or by documentation of an associated disability, we believe that the data collected by the assessment tools will have sufficient granularity and allow for disaggregation to understand what is the incidence/prevalence of a particular morbidity category, and what is the incidence/prevalence of the associated disability according to the women. Both count. In this regard, this work also coincides with the ongoing revision of the ICD. The theoretical need to "count" morbidities or clinical conditions and the women-reported outcomes inform the broader discussion of trying to understand what we measure and why.

Such discourse is particularly important as the global community debates the post-2015, Sustainable Development Goals (SDGs) agenda, with special attention to universal health coverage (UHC) as an important aspect to improve health and contribute to development of populations [27]. With regard to maternal health post-2015 goal and targets, the underlying strategies towards the Ending Preventable Maternal Mortality (EPMM) are intended to address the overall health needs of girls and women [28]. Articulated within the strategic objectives towards EPMM is the need "to address all causes of maternal mortality, reproductive and maternal morbidities, and related disabilities" and to ensure UHC for accessing care [28]. This is based upon the premise that improved information on morbidity and its lasting consequences, is also likely to expose the inter-related nature of pregnancy care to other aspects of the health sector as well as non-health sectors (e.g. environment, transportation, financing). Its most important contribution will be, however, in enhancing health system response to maternal morbidity, including strengthening evidence for the determination of packages for UHC, key means to improve access to health care and improve health of populations.

Development of a standard definition and framework for maternal morbidity is rife with challenges and the maternal morbidity matrix is a practical framework for assessing maternal morbidity beyond near-miss. In light

of the emerging attention to UHC as part of the post-2015 SDGs planning, a definition and standard identification criteria are essential to measuring its extent and impact. As the international community looks at the decreases in maternal mortality, there is an urgent tandem need to define and measure maternal morbidity. Looking beyond 2015, this is an investment we cannot afford to ignore.

Abbreviations

EPMM: Ending Preventable Maternal Mortality; ICD: International Statistical Classification of Diseases and related health problems; ICD-MM: WHO Application of ICD-10 to deaths during pregnancy, childbirth and the puerperium: ICD-Maternal Mortality; ICF: International Classification of Functioning, Disability and Health; InterSAMM: Interpreting Severe Acute Maternal Morbidity; InterVA-4: Interpreting Verbal Autopsy - 4; LMICs: Low and Middle Income Countries; MDG: Millennium Development Goal; MMWG: Maternal Morbidity Working Group; SDGs: Sustainable Development Goals; UHC: Universal Health Coverage; WHO: World Health Organization; WHODAS 2.0: WHO Disability Assessment Schedule 2.0.

Competing interests

The author(s) declare that they have no competing interests.

Authors' contributions

LS, DC, and ÖT led the definition and matrix construction process and developed the text. MB supported the development of the text. TF, VF, PvD, NvD, JGC, and the MMWG contributed to the development of the methodology and rationale behind the definition and matrix. All authors read and approved the final manuscript.

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References

1. Ronsmans C, Graham WJ. Maternal survival 1 - Maternal mortality: who, when, where, and why. Lancet. 2006;368(9542):1189–200. doi:10.1016/S01406736(06)69380-X.
2. Firoz T, Chou D, von Dadelszen P, Agrawal P, Vanderkruik R, Tuncalp O, et al. Measuring maternal health: focus on maternal morbidity. Bull World Health Organ. 2013;91(10):794–6. doi:10.2471/BLT.13.117564.
3. Vanderkruik RC, Tuncalp O, Chou D, Say L. Framing maternal morbidity: WHO scoping exercise. BMC Pregnancy Childbirth. 2013;13(1):213. doi:10.1186/1471-2393-13-213.
4. World Health Organization. Trends in Maternal Mortality: 1990 to 2015. Estimates by WHO, UNICEF, UNFPA, The World Bank and the United Nations Population Division 2015.
5. World Health Organization. Evaluating the quality of care for severe pregnancy complications: the WHO near-miss approach for maternal health. Geneva: WHO; 2011.
6. Bang RA, Bang AT, Reddy MH, Deshmukh MD, Baitule SB, Filippi V. Maternal morbidity during labour and the puerperium in rural homes and the need for medical attention: A prospective observational study in Gadchiroli, India. BJOG. 2004;111(3):231–8.
7. Walraven G, Scherf C, West B, Ekpo G, Paine K, Coleman R, et al. The burden of reproductive-organ disease in rural women in The Gambia, West Africa. Lancet. 2001;357(9263):1161–7. doi:10.1016/S0140-6736(00)04333-6.
8. World Health Organization. The International Classification of Diseases 11th Revision is due by 2017. http://www.who.int/classifications/icd/revision/en/. Accessed 23 February 2015.
9. Reerink IH, Sauerborn R. Quality of primary health care in developing countries: recent experiences and future directions. International J Qual Health Care. 1996;8(2):131–9.
10. Oladapo OT, Iyaniwura CA, Sule-Odu AO. Quality of antenatal services at the primary care level in southwest Nigeria. Afr J Reprod Health. 2008;12(3):21.
11. Say L, Souza JP, Pattinson RC. Maternal near miss–towards a standard tool for monitoring quality of maternal health care. Best Pract Res Clin Obstet Gynaecol. 2009;23(3):287–96. doi:10.1016/j.bpobgyn.2009.01.007.
12. Tuncalp O, Were WM, MacLennan C, Oladapo OT, Gulmezoglu AM, Bahl R, et al. Quality of care for pregnant women and newborns-the WHO vision. BJOG. 2015;122(8):1045–9. doi:10.1111/1471-0528.13451.
13. Filippi V, Ronsmans C, Gandaho T, Graham W, Alihonou E, Santos P. Women's Reports of Severe (Near-miss) Obstetric Complications in Benin. Stud Fam Plann. 2000;31(4):309–24. doi:10.1111/j.1728-4465.2000.00309.x.
14. Montgomery A, Goufodji S, Kanhonou L, Alihonou E, Collin S, Filippi V. Validity and reliability of postpartum morbidity questionnaires in Benin. Matern Child Health J. 2012;16(8):1728–31. doi:10.1007/s10995-011-0859-9.
15. World Health Organization. WHO definition of Health. Geneva, Switzerland. http://www.who.int/about/definition/en/print.html. Accessed 26 November 2013.
16. World Health Organization. International Classification of Functioning, Disability and Health (ICF); 2013.
17. World Health Organization. The WHO Application of ICD-10 to deaths during pregnancy, childbirth and the puerperium: ICD-MM; 2012.
18. World Health Organization. Classifications: WHO Disability Assessment Schedule 2.0 - WHODAS 2.0. 2014. http://www.who.int/classifications/icf/whodasii/en/. Accessed 07 August 2014.
19. Say L, Chou D, Gemmill A, Tunçalp O, Moller A, Daniels J, et al. Global causes of maternal death: a WHO systematic analysis. Lancet Glob Health. 2014;2(6):e323–33.
20. Souza JP, Tunçalp Ö, Vogel JP, Bohren M, Widmer M, Oladapo OT, et al. Obstetric transition: the pathway towards ending preventable maternal deaths. BJOG. 2014;121:1–4. doi:10.1111/1471-0528.12735.
21. Kayem G, Kurinczuk J, Lewis G, Golightly S, Brocklehurst P, Knight M. Risk factors for progression from severe maternal morbidity to death: a national cohort study. PLoS One. 2011;6(12):e29077. doi:10.1371/journal.pone.0029077.
22. GAVI Alliance. Non-communicable diseases: A priority for women; 2012.
23. Hatzichristou D, Rosen RC, Derogatis LR, Low WY, Meuleman EJ, Sadovsky R, et al. Recommendations for the clinical evaluation of men and women with sexual dysfunction. J Sex Med. 2010;7(1 Pt 2):337–48. doi:10.1111/j.1743-6109.2009.01619.x.
24. Byass P, Chandramohan D, Clark SJ, D'Ambruoso L, Fottrell E, Graham WJ, et al. Strengthening standardised interpretation of verbal autopsy data: the new InterVA-4 tool. Glob Health Action. 2012;5:1–8. doi:10.3402/gha.v5i0.19281.
25. Byass P, Calvert C, Miiro-Nakiyingi J, Lutalo T, Michael D, Crampin A, et al. InterVA-4 as a public health tool for measuring HIV/AIDS mortality: a validation study from five African countries. Glob Health Action. 2013;6:22448. doi:10.3402/gha.v6i0.22448.
26. Fottrell E, Högberg U, Ronsmans C, Osrin D, Azad K, Nair N, et al. A probabilistic method to estimate the burden of maternal morbidity in resource-poor settings: preliminary development and evaluation. Emerg Themes Epidemiol. 2014;11(3):11.
27. Bustreo F, Say L, Koblinsky M, Pullum TW, Temmerman M, Pablos-Mendez A. Ending preventable maternal deaths: the time is now. Lancet Global Health. 2013;1(4):e176–e7.

28. World Health Organization, editor. Strategies toward ending preventable maternal mortality (EPMM) - The EPMM Working Group invites comments on the draft paper. Consultation on targets and strategies for ending preventable maternal mortality (EPMM); 2014; Bangkok, Thailand. Online.
29. World Health Organization. How to use the ICF: A Practical Manual for using the International Classification of Functioning, Disability and Health (ICF). Exposure draft for comment; 2013.