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SPECIAL ARTICLE

Definition and Prioritization of Data Elements for Cohort Studies and Clinical Trials on Patients with Unruptured Intracranial Aneurysms: Proposal of a Multidisciplinary Research Group

Katharina A. M. Hackenberg[1*], Ale Algra[2], Rustam Al-Shahi Salman[3], Juhana Frösen[4], David Hasan[5], Seppo Juvela[6], David Langer[7], Philip Meyers[8], Akio Morita[9], Gabriel Rinkel[10†] and Nima Etminan[1†] on behalf of the Unruptured Aneurysms and SAH CDE Project Investigators

Abstract

Introduction: Variability in usage and definition of data characteristics in previous cohort studies on unruptured intracranial aneurysms (UIA) complicated pooling and proper interpretation of these data. The aim of the National Institute of Health/National Institute of Neurological Disorders and Stroke UIA and Subarachnoid Hemorrhage (SAH) Common Data Elements (CDE) Project was to provide a common structure for data collection in future research on UIA and SAH.

Methods: This paper describes the development and summarization of the recommendations of the working groups (WGs) on UIAs, which consisted of an international and multidisciplinary panel of cerebrovascular specialists on research and treatment of UIAs. Consensus recommendations were developed by review of previously published CDEs for other neurological diseases and the literature on UIAs. Recommendations for CDEs were classified by priority into 'Core,' 'Supplemental—Highly Recommended,' 'Supplemental,' and 'Exploratory.'

Results: Ninety-one CDEs were compiled; 69 were newly created and 22 were existing CDEs. The CDEs were assigned to eight subcategories and were classified as Core (8), Supplemental—Highly Recommended (23), Supplemental (25), and Exploratory (35) elements. Additionally, the WG developed and agreed on a classification for aneurysm morphology.

Conclusion: The proposed CDEs have been distilled from a broad pool of characteristics, measures, or outcomes. The usage of these CDEs will facilitate pooling of data from cohort studies or clinical trials on patients with UIAs.

Keywords: Common data elements, Unruptured intracranial aneurysms, Risk factors, Morphology, Data standardization

*Correspondence: katharina.hackenberg@umm.de
†Gabriel Rinkel and Nima Etminan have contributed equally to this work.
[1] Department of Neurosurgery, University Hospital Mannheim, University of Heidelberg, Mannheim, Germany
Full list of author information is available at the end of the article

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Introduction

Around 3% of the adult global population has unruptured intracranial aneurysms (UIAs) [1]. The increased usage and improved quality of cranial imaging have resulted in more frequent detection of these lesions. UIAs can remain clinically asymptomatic, present with focal neurological deficits from local mass effect or ischemia, or they may rupture. Rupture of an aneurysm results in aneurysmal subarachnoid hemorrhage (SAH), which has a case fatality rate up to 35% and a high risk for permanent neurological disabilities as well as neuropsychological disorders in survivors [2, 3].

Previous meta-analyses on development or rupture of UIAs have been hampered by varying definitions of risk factors, which sometimes led to inconsistent results [4, 5]. In a pooled analysis of individual patient data from six prospective cohort studies, six easily retrievable predictors enabled the calculation of the 5-year risk of aneurysm rupture: population, hypertension, patient age, aneurysm size, earlier SAH from another aneurysm, and aneurysm site. However, several other potential risk factors, such as smoking status during follow-up or aneurysm morphology, could not be included in the risk score because data were not collected at all or with varying methods [5, 6].

The Common Data Elements (CDE) project for standardizing data for neurological clinical research was initiated by cerebrovascular clinicians and scientists under the auspices of The National Institute of Neurological Disorders and Stroke to facilitate pooling and comparison of such data on cerebrovascular disease.

Process for Selecting CDEs

For a description of the UIA and SAH CDE project, we refer to the main article of this project [7]. For development of CDEs for the WG 'UIA' of 'UIA and SAH,' a multidisciplinary and international group of nine cerebrovascular specialists on research and treatment of UIAs was assembled by the two work group (WG) co-chairs (NE, GJER) (Fig. 1). Following systematic review and collection of the current data on UIAs by the two co-chairs, existing CDEs on ischemic stroke were integrated in data sheets. These were circulated to all WG members and subsequently reviewed, expanded, or modified by each member. Additionally, the WG developed a proposal for classification of aneurysm morphology based on current data. Further, CDEs that apply to multiple WGs (e.g., aneurysm size or location in the imaging WG) were crosschecked and/or adapted with these subcommittees to exclude heterogeneous definitions of the same CDEs.

Finally, the CDEs were categorized into four groups: (1) Core CDEs—elements which can be consistently collected across studies and which should be employed in studies concerning the corresponding particular disease or therapeutic area; (2) Supplemental—Highly Recommended CDEs—elements that are essentially based on certain conditions or study types in clinical research studies and that are strongly recommended for the specific disease or therapeutic area; (3) Supplemental CDEs—elements that are commonly collected in clinical research studies, but whose relevance depends on the study design or type of research; and 4. Exploratory CDEs—elements which are reasonable to use, but whose validity is yet limited due to insufficient availability and validation of data. The categorization was proposed by the two co-chairs, and after another round of review and revision of all CDEs, all the WG members agreed on the final proposal of the UIA CDEs. These findings were presented at the 4th Neurocritical Care Research Conference in Houston, Texas, May 2016, for further review and revision within the SAH CDE research group. The final version of the CDEs was once more circulated within the WG, and upon agreement, the final case report forms were developed.

Common Data Elements Overview

The 'UIA' WG collected 91 CDEs, 69 new CDEs, and 22 already established CDEs where only minor changes had to be made for our purposes. The CDEs were divided into eight categories: demographics, reason of medical consult and diagnosis, clinical symptoms and assessment at baseline, risk factors, concomitant medications, concomitant diseases, radiological findings, as well as management of unruptured aneurysms. Each CDE was assigned a specific identification number, a CDE name, variable name, definition, classification, permissible values, a code name, a code description and if necessary, a unit of measure and a question text.

The CDEs were classified as 8 Core (see below), 23 Supplemental—Highly Recommended, 25 Supplemental, and 35 Exploratory elements (Tables 1–8).

Description of Core CDEs

Demographics (Table 1).

- Patient age (preexisting CDE) [5, 8–10].
- Risk factors (Table 4).
- Hypertension (defined as systolic blood pressure greater than or equal to 140 mmHg or greater than or equal to 90 mmHg diastolic in adults or systolic or diastolic blood pressure above the 95 percentile in children) (preexisting CDE) [5, 8, 11–13].
- Tobacco smoking status: (a) never, (b) former (including start and end date of smoking), (c) current (including starting date) and (d) unknown (modified CDE) [1, 9–17].

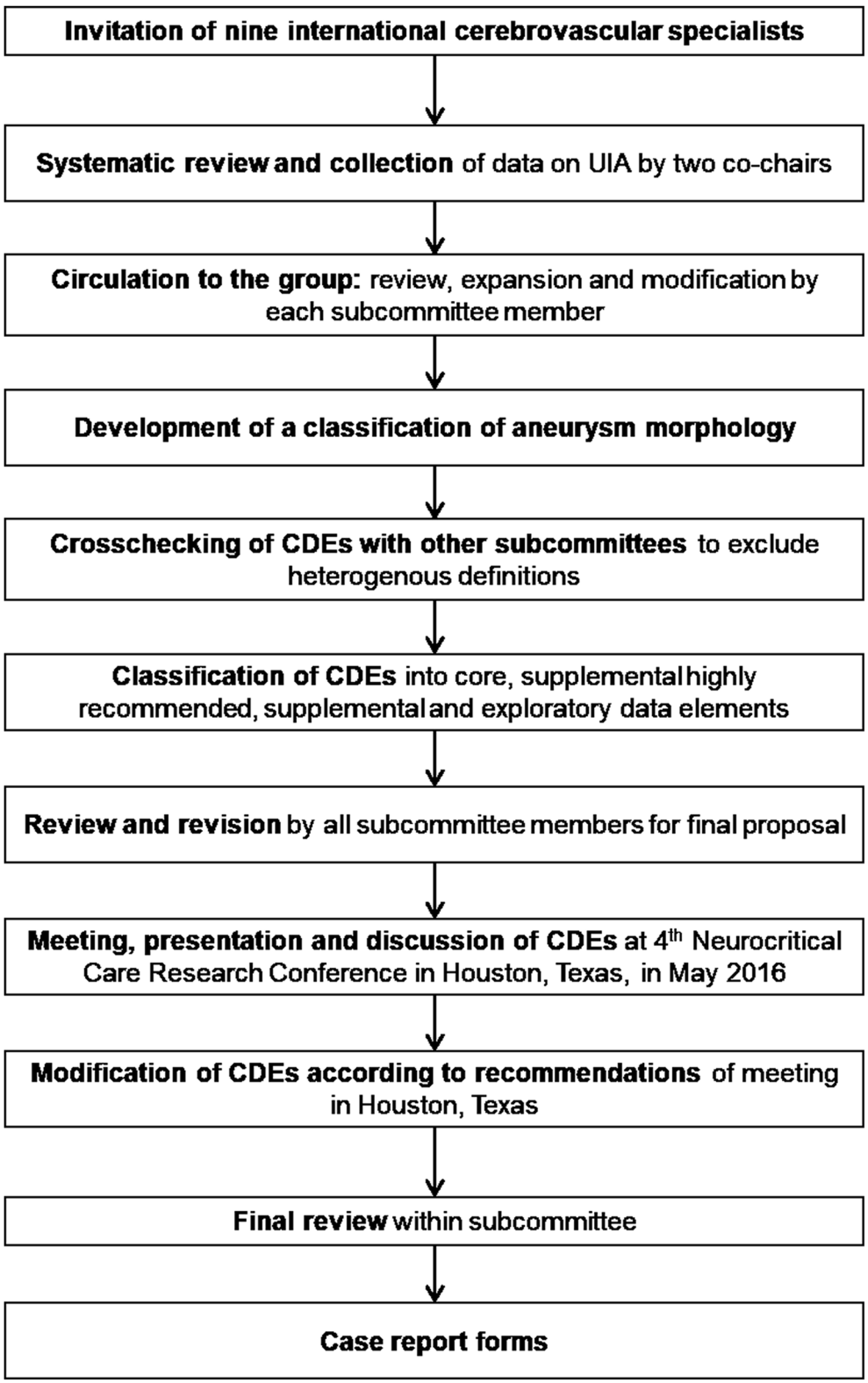

Fig. 1 Development of CDEs

Table 1 CDEs—demographics

CDE ID	CDE name	Definition	Permissible value	Classification
C00008	Age value	Value for participant/subject's age, calculated as elapsed time since the birth of the participant/subject		Core
C20391	Sex participant or subject genotype type	The difference between male and female, based upon the interactions between genes and between the genotype and the environment. Genotype is identified based on the individual's reproductive organs and functions assigned by chromosomal complement	Male; female	Supplemental—Highly Recommended
C16174 modified	Menopause indicator	Indicates whether participant/subject is currently menopausal, if yes: age at begin of menopause	No; yes	Exploratory

CDE common data element, *ID* identification number

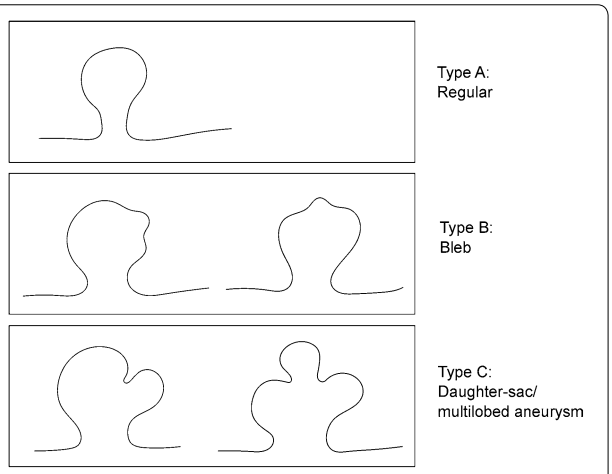

Fig. 2 Classification of aneurysm morphology

Radiological findings (Table 7).

- Anatomical aneurysm site based on angiography (modified CDE) [5, 9, 18–26].
- Maximum aneurysm diameter (in mm) in any direction (new CDE) [5, 8, 9, 16–20, 22–29].
- Maximum aneurysm height (in mm) perpendicular to aneurysm neck (new CDE) [30].
- Maximum aneurysm width (in mm) perpendicular to aneurysm height (new CDE) [30].
- Aneurysm morphology type: (a) regular, (b) bleb, (c) daughter-sac/multilobed aneurysm (new CDE, Fig. 2) [20–23, 27, 30–33].

Description of UIA CDEs

For 'reason of medical consult and diagnosis,' one CDE with eight permissible values was established (Table 2). The subtopic 'clinical symptoms and assessment at baseline' contains eight CDEs, of which three were novel and the remaining were edited (Table 3). Twelve CDEs on 'risk factors' were established, comprised of six novel and six reutilized CDE. Permissible values and further information were added to the CDE 'tobacco smoke history status' as a core item (Table 4). Additionally, a classification concerning the morphology of an aneurysm was established (Fig. 2). There are 10 CDEs in the subtopic 'concomitant medications,' of which seven were novel and three were modified (Table 5). The subject area 'concomitant diseases' contains 21 novel CDEs and three already established CDEs (Table 6). For 'radiological findings,' we compiled 27 CDEs, out of these the CDE 'imaging modality vessel imaging angiography type' was reused and permissible values were added to the Stroke CDE 'imaging vessel angiography aneurysm' (Table 7). Six novel CDEs were established for 'UIA management' (Table 8).

Limitations

This project has limitations: We identified and defined numerous data elements in the setting of UIAs, based on existing and/or most commonly used definitions. We balanced between very detailed definitions, which would decrease the feasibility of using these, and broad

Table 2 CDEs—reason of medical consult and diagnosis

CDE ID	CDE name	Definition	Permissible value	Classification
NEW	Unruptured intracranial aneurysm reason medical consult diagnosis	Reason of medical consult and diagnosis of unruptured intracranial aneurysm	Screening of CNS during checkup of general health; evaluation of vague symptoms such as headache, vertigo, dizziness; symptoms probably related to aneurysm (cranial nerve palsies, embolic events, etc.); cerebrovascular imaging because of TIA, ischemic, or hemorrhagic stroke; evaluation of SAH (UIAs associated with other aneurysm caused SAH); familial screening; screening because of ADPKD; other	Supplemental

ADPKD autosomal-dominant polycystic kidney disease, *CDE* common data element, *CNS* central nervous system, *ID* identification number, *SAH* subarachnoid hemorrhage, *TIA* transient ischemic attack, *UIA* unruptured intracranial aneurysm

Table 3 CDEs—clinical symptoms and assessment at baseline

CDE ID	CDE name	Definition	Permissible value	Classification
C14434 modified	Cranial nerve abnormal identifier	The identified cranial nerve that assessed as abnormal due to unruptured intracranial aneurysm	CN II; CN III; CN IV; CN V; CN VI; CN VII; CN VIII; CN IX; CN X; CN XI; CN XII	Supplemental
C14438	Motor examination global abnormality present indicator	Global assessment whether an abnormality was present following the motor examination	Yes; no; not assessable	Supplemental
C14466	Sensory system global assessment result	The condition and ability of sensory system	Normal; abnormal; not assessable; other, specify	Supplemental
NEW	Speech disturbance global assessment	Global Assessment of speech disturbance	Normal; dysarthria; amnesic dysphasia; aphasia; other, specify	Supplemental
NEW	Symptoms unruptured intracranial aneurysm mass effect	Clinical signs for mass effect due to aneurysm without SAH	Progressive headache; nausea; vomiting; focal neurological findings, if yes, specify; other, specify	Supplemental
NEW	Sentinel headache aneurysm	Presence or history of a sentinel headache/thunderclap	Yes; no	Supplemental
C05460	Seizure indicator	Indicator of seizure activity	Yes; no	Supplemental
C13230 modified	Modified Rankin Scale (mRS) score	The overall modified Rankin Scale (mRS) score assigned to the participant/subject (at baseline)	0 (no symptoms at all); 1 (no significant disability; despite symptoms, able to carry out all usual duties and activities); 2 (slight disability; unable to perform all previous activities but able to look after own affairs without assistance); 3 (moderate disability; requiring some help but able to walk without assistance); 4 (moderately severe disability; unable to walk without assistance and unable to attend to own bodily needs without assistance); 5 (severe disability; bedridden, incontinent and requiring constant nursing care and attention);	Supplemental

CDE common data element, *CN* cranial nerve, *ID* identification number, *SAH* Subarachnoid hemorrhage

definitions, which are easier to use in clinical practice, but may provide less scientific details. Thus, the definitions and their scientific implication remain uncertain and need to be validated prospectively. Further, for several CDEs, we had to define limits or cut-off values. For example, for hypertension, we used the accepted definitions of the cardiac guidelines, a systolic pressure of 140 mmHg and a diastolic one of 90 mmHg, but it remains uncertain whether these cut-off values for hypertension are clinically relevant in terms of risk factor for growth or rupture. Further, a consensus approach was used to define and rank the individual importance of data elements based on existing literature. Thus, other potentially relevant data elements suggested by experimental or case–control studies could not be included at present because of the lack of validated measurement tools or grading scales for such outcomes (e.g., aneurysm wall inflammation in imaging studies). Additionally, the WG established and agreed on a novel classification system for aneurysm morphology, for which there were no immediate data from the previous cohort or case–control studies to support this exact classification. However, since three-dimensional aneurysm morphologies are difficult to measure or to describe in standardized manner, the WG agreed on a two-dimensional classification as a basis for further research. Lastly, the established CDEs on UIAs may need to be adapted or even expanded, e.g., with neurocognitive outcome measures and grading scales in patients undergoing preventive UIA repair or follow-up imaging in the future, if there are sufficient data to support this. Despite these limitations, standardized collection of the proposed CDEs will at least provide data on whether the CDEs as currently defined are risk factors for the development and rupture of intracranial aneurysms.

Next Steps/Future Work

Future clinical studies need to test and validate the sensitivity and relative importance of the UIA CDEs established. Furthermore, data should be derived from more

Table 4 CDEs—risk factors

CDE ID	CDE name	Definition	Permissible value	Classification
NEW	Familial history unruptured intracranial aneurysm or subarachnoid hemorrhage indicator	Familial history of 2 or more first-degree relatives with unruptured intracranial aneurysms or with history of subarachnoid hemorrhage due to an intracranial aneurysm	Yes; no	Supplemental—Highly Recommended
NEW	Familial history aneurysmal subarachnoid hemorrhage	Presence of aneurysmal subarachnoid hemorrhage in family	Father; mother; son; daughter; brother; sister; other: male or female	Supplemental—Highly Recommended
C05454	Hypertension indicator	Indicator of hypertension. In adults, hypertension is defined as a systolic pressure ≥ 140 and a diastolic ≥ 90. In children, it is defined as systolic blood pressure > 95th percentile for age	Yes; no; suspected; unknown	Core
C19565 modified	Blood pressure measurement	Blood pressure measurement with systolic measurement over diastolic measurement		Supplemental—Highly Recommended
C06102 modified	Tobacco smoke history status	Qualitative categorization of the participant's/subject's smoking history	Never smoked; former smoker; current smoker; unknown	Core
C00709	Tobacco cigarettes smoked daily average number	Average number of cigarettes the participant/subject smokes daily (on the days you smoked cigarettes during the past 30 days, how many cigarettes did you smoke per day, on average?)	Less than 1 cigarette per day; 1 cigarette per day; 2–5 cigarettes per day; 6–15 cigarettes per day (about 1/2 pack); 16–25 cigarettes per day (about 1 pack); 26–35 cigarettes per day (about 1 1/2 packs); more than 35 cigarettes per day (about 2 packs or more); unknown	Supplemental—Highly Recommended
C06108	Tobacco smoke pack-year value	If participant is a former or current cigarette smoker, documents the number of pack-years of smoking [(average number smoked daily)/20] × (number of years smoked) = pack-years]		Supplemental—Highly Recommended
NEW	Alcohol use weekly measurement	Alcohol consumption of ≥ 210 g ethanol per week (7 × 3 glasses per day)	Yes; no	Supplemental—Highly Recommended
NEW	Disease autosomal-dominant polycystic kidney	Presence of autosomal-dominant polycystic kidney disease	Yes; no	Supplemental—Highly Recommended
NEW	History previous subarachnoid hemorrhage other intracranial aneurysm	History of previous subarachnoid hemorrhage due to another intracranial aneurysm	Yes; no	Supplemental—Highly Recommended
NEW	Ethnicity intracranial aneurysm	Ethnicity/ancestry of patient	Non-Japanese; non-finnish; Japanese; finnish	Supplemental—Highly Recommended
C11131 modified	Body mass index value	Value of the participant/subject's body mass index, calculated from height and weight		Exploratory

CDE common data element, *ID* identification number

Table 5 CDEs—concomitant medications

CDE ID	CDE name	Definition	Permissible value	Classification
NEW	Medication antihypertensive type	History of or current intake of type of antihypertensive medication	Thiazide diuretics; calcium channel blockers; ACE inhibitors; angiotensin II receptor blockers; β-blockers; α-blockers;	Supplemental
NEW	Medication antihypertensive current former take duration	Duration in months for which the subject/participant took or has taken the selected former or current antihypertensive medication		Supplemental
NEW	Medication antihypertensive current former take age start value	Age in years at which the subject/participant began taking the selected former or current antihypertensive medication		Supplemental
NEW	Medication antihypertensive former take age end value	Age in years at which the subject/participant stopped taking the selected former antihypertensive medication		Supplemental
C14632 modified	Antiplatelet type	Type(s) of antiplatelets received	Aspirin; aspirin/dipyridamole (in separate formulations or as Aggrenox); clopidogrel; ticlopidine; other, specify	Supplemental
NEW	Medication antiplatelet current former take duration	Duration in months for which the subject/participant took or has taken the selected former or current antiplatelet medication		
NEW	Medication antiplatelet current former take age start value	Age in years at which the subject/participant began taking the selected former or current antiplatelet medication		
NEW	Medication antiplatelet former take age end value	Age in years at which the subject/participant stopped taking the selected former antiplatelet medication		
NEW	Medication statin	History of or current intake of type of statins		Exploratory
NEW	Medication statin current former take duration	Duration in months for which the subject/participant took or has taken the specified former or current statin medication		Exploratory
NEW	Medication statin current former take age start value	Age in years at which the subject/participant began taking the specified former or current statin medication		Exploratory
NEW	Medication statin former take age end value	Age in years at which the subject/participant stopped taking the specified former statin medication		Exploratory
C10981 modified	Birth control method type	The female participant's/subject's method of birth control	Oral contraceptives—combined pill; oral contraceptives—progestin-only pill; transdermal patch; shot/injection; abstinence; hormonal (e.g., oral, implanted, injected); none of these; other, specify	Exploratory
NEW	Birth control method current former use duration	Duration in months for which the subject/participant used the selected current or former birth control method		Exploratory

Table 5 (continued)

CDE ID	CDE name	Definition	Permissible value	Classification
NEW	Birth control method current former use age start value	Value in years of the age at which the subject/participant began to use the selected current or former birth control method		Exploratory
NEW	Birth control method former use age end value	Value in years of the age at which the subject/participant ended use of the selected former birth control method		Exploratory
NEW	Medication non-steroidal anti-inflammatory drugs (NSAIDs)	History of or current intake of type of NSAID		Exploratory
NEW	Non-steroidal anti-inflammatory drug current former take duration	Duration in months for which the subject/participant took or has taken the specified non-steroidal anti-inflammatory drug (NSAID)		Exploratory
NEW	Non-steroidal anti-inflammatory drug current former take age start value	Age in years at which the subject/participant began taking the specified former or current non-steroidal anti-inflammatory drug (NSAID)		Exploratory
NEW	Non-steroidal anti-inflammatory drug former take age end value	Age in years at which the subject/participant stopped taking the specified former non-steroidal anti-inflammatory drug (NSAID)		Exploratory
NEW	Hormone therapy	History of or current intake of type of hormones		Exploratory
NEW	Hormone therapy current former receive duration	Duration in months for which the subject/participant took or has taken the specified hormone therapy		Exploratory
NEW	Hormone therapy current former receive age start value	Age in years at which the subject/participant began taking the specified former or current hormone therapy		Exploratory
NEW	Hormone therapy former receive age end value	Age in years at which the subject/participant stopped taking the specified former hormone therapy		Exploratory
C14630 modified	Anticoagulant type	Type(s) of anticoagulants received	Unfractionated heparin IV; full dose LMW heparin; warfarin; phenprocoumon; acenocumarol; dabigatran; fondaparinux; rivaroxaban; apixaban; edoxaban; other, specify	Supplemental
NEW	Medication anticoagulant current former take duration	Duration in months for which the subject/participant took or has taken the selected former or current anticoagulant medication		Supplemental
NEW	Medication anticoagulant current former take age start value	Age in years at which the subject/participant began taking the selected former or current anticoagulant medication		Supplemental
NEW	Medication anticoagulant former take age end value	Age in years at which the subject/participant stopped taking the selected former anticoagulant medication		Supplemental

Table 5 (continued)

CDE ID	CDE name	Definition	Permissible value	Classification
NEW	Stimulants	History of or current intake of type of stimulants	Amphetamine derivatives; caffeine (xanthine derivative); theophyllin (xanthine derivative); theobromin (xanthine derivative); cocaine; others, specify	Supplemental
NEW	Stimulant current former use duration	Duration in months for which the subject/participant took or has taken the selected former or current stimulant		Supplemental
NEW	Stimulant current former use age start value	Age in years at which the subject/participant began taking the selected former or current stimulant		Supplemental
NEW	Stimulant former use age end value	Age in years at which the subject/participant stopped taking the selected former stimulant		Supplemental
NEW	Medication immunosuppressant	History of or current intake of type of immunosuppressants	Corticosteroids systemic; corticosteroids local; others, specify	Exploratory
NEW	Medication immunosuppressant current former take duration	Duration in months for which the subject/participant took or has taken the selected former or current immunosuppressant medication		
NEW	Medication immunosuppressant current former take age start value	Age in years at which the subject/participant began taking the selected former or current immunosuppressant medication		
NEW	Medication immunosuppressant former take age end value	Age in years at which the subject/participant stopped taking the selected former immunosuppressant medication		
NEW	Medication potency-enhancing	History of or current intake of potency-enhancing medications		Exploratory
	Potency-enhancing drug current former use duration	Duration in months for which the subject/participant took or has taken the specified potency-enhancing drug		
	Potency-enhancing drug current former use age start value	Age in years at which the subject/participant began taking the specified former or current potency-enhancing drug		
	Potency-enhancing drug former use age end value	Age in years at which the subject/participant stopped taking the specified potency-enhancing drug		

CDE common data element, *ID* identification number, *NSAID* non-steroidal anti-inflammatory drug

Table 6 CDEs—concomitant diseases

CDE ID	CDE name	Definition	Permissible value	Classification
NEW	Disease chronic renal	History of or present chronic renal disease	Yes; no	Exploratory
NEW	Disease autosomal-dominant polycystic kidney	Presence of autosomal-dominant polycystic kidney disease	Yes; no	Supplemental—Highly Recommended
NEW	Disease renal artery stenosis	History of or present renal artery stenosis	Yes; no	Exploratory
NEW	Disease coronary artery	History of or present coronary artery disease	Yes; no	Exploratory
NEW	Disease peripheral artery	History of or present peripheral artery disease	Yes; no	Exploratory
NEW	Disease carotid artery	History of or present carotid artery disease	Yes; no	Exploratory
NEW	Disease valve	History of or present valve disease	Yes; no	Exploratory
NEW	Disease aortic coarctation	History of or present aortic coarctation	Yes; no	Supplemental
NEW	Disease aortic aneurysm	History of or present aortic aneurysm	Yes; no	Exploratory
NEW	Disease gingival, tooth decay	History of or present gingival disease, tooth decay	Yes; no	Exploratory
NEW	Disease intracranial atherosclerotic	History of or present intracranial atherosclerotic disease	Yes; no	Exploratory
NEW	Disease arteriovenous malformation	History of or present arteriovenous malformation	Yes; no	Exploratory
NEW	Disease dural arteriovenous fistula	History of or present dural arteriovenous fistula	Yes; no	Exploratory
NEW	Disease CNS tumor	History of or present CNS tumor	Yes; no	Exploratory
NEW	History previous cranial surgery	History of previous cranial surgery	Yes; no	Exploratory
C13758	Imaging diagnosis stroke transient ischemic attack indicator	Indicates the diagnosis of stroke/transient ischemic attack (TIA) for imaging positive	Yes; no; unknown	Exploratory
NEW	Disease fibromuscular	History of or present fibromuscular disease	Marfan syndrome; Ehlers–Danlos syndrome; other, specify	Supplemental
NEW	Disease sepsis	History of or present sepsis	Yes; no	Exploratory
NEW	Disease transplant	History of or present transplant	Yes; no	Exploratory
C05460	Seizure indicator	Indicator of seizure activity	Yes; no	Supplemental
C06358	Diabetes mellitus type	Type of diabetes mellitus	Type 1; type 2	Exploratory
NEW	Disease hyperlipidemia	History of or present hyperlipidemia	Yes; no	Exploratory
NEW	Disease coagulopathies	History of or present type of coagulopathy	Hemophilia; von Willebrand disease; other	Supplemental
NEW	Disease thrombophilic	History of or present type of thrombophilic disease	Factor V Leiden; antiphospholipid syndrome; antithrombin III deficiency; protein c/s deficiency; other	Supplemental

CDE common data element, *CNS* central nervous system, *ID* identification number

Table 7 CDEs—radiological findings

CDE ID	CDE name	Definition	Permissible value	Classification
NEW	Imaging unruptured intracranial aneurysm mass effect	Radiological signs for mass effect due to aneurysm	Edema; midline shift; cranial nerve compression; herniation	Exploratory
NEW	Imaging unruptured intracranial aneurysm ischemia infarction	Imaging of any ischemic lesion or infarction related to aneurysm location/parent artery	Yes; no	Exploratory
C13879	Imaging modality vessel imaging angiography type	Imaging modality for vessel imaging angiography	DSA; MRA; CTA	Supplemental—Highly Recommended
C13884 modified	Imaging vessel angiography aneurysm anatomical site	Anatomical site of aneurysms in vessel imaging angiography	C1 cervical; C2 petrous; C3 lacerum; C4 cavernous; C5 clinoidal; C6—ophthalmic to PCOM; C6—PCOM to terminus; PCOM; A1; ACOM; A2; M1 proximal to striate; M1 distal to striate; M2; M3; M4; vertebral origin; vertebral—cervical; vertebral—intracranial proximal to PICA; Vertebral—distal to PICA; basilar—distal to AICA; basilar—mid; basilar—proximal to AICA; P1; P2; P3; SCA; AICA; PICA	Core
NEW	Imaging unruptured intracranial aneurysm side	Aneurysm side for each unruptured intracranial aneurysm	Right; left; midline	Supplemental—Highly Recommended
NEW	Imaging unruptured intracranial aneurysm count	Number of unruptured intracranial aneurysms		Supplemental—Highly Recommended
NEW	Imaging unruptured intracranial aneurysm maximum diameter	Largest diameter in any direction for each unruptured intracranial aneurysm		Core
NEW	Imaging unruptured intracranial aneurysm height	Largest diameter perpendicular to neck of aneurysm for each unruptured intracranial aneurysm		Core
NEW	Imaging unruptured intracranial aneurysm width	Largest diameter perpendicular to height of aneurysm for each aneurysm		Core
NEW	Imaging aneurysm neck measurement	Largest diameter/width of aneurysm neck for each aneurysm		Supplemental—Highly Recommended
NEW	Imaging aneurysm aspect ratio value	Largest height/largest neck diameter for each aneurysm		Supplemental—Highly Recommended
NEW	Imaging unruptured intracranial aneurysm size ratio	Largest height/largest diameter of parent artery for each aneurysm		Supplemental—Highly Recommended
NEW	Imaging unruptured intracranial aneurysm bottle neck factor	Largest aneurysm width/largest neck width		Supplemental—Highly Recommended
NEW	Imaging unruptured intracranial aneurysm diameter parent artery proximal	Diameter of parent artery proximal to unruptured intracranial aneurysm		Supplemental
NEW	Imaging unruptured intracranial aneurysm diameter parent artery distal	Diameter of parent artery distal to unruptured intracranial aneurysm		Supplemental
NEW	Imaging unruptured intracranial aneurysm sidewall branch count	Number of sidewall branches for each unruptured intracranial aneurysm		Supplemental

Table 7 (continued)

CDE ID	CDE name	Definition	Permissible value	Classification
NEW	Imaging unruptured intracranial aneurysm pre-aneurysmal parent artery stenosis	Presence of stenosis of pre-aneurysmal parent artery for each unruptured intracranial aneurysm	Yes; no	Exploratory
NEW	Imaging unruptured intracranial aneurysm contralat stenoocclusive vessel disease	Presence of contralateral stenoocclusive vessel disease	Yes; no	Exploratory
NEW	Imaging unruptured intracranial aneurysm calcification	Presence of calcification in aneurysm for each unruptured intracranial aneurysm	Yes; no	Supplemental
NEW	Imaging aneurysm thrombus indicator	Presence of mural thrombus or partial thrombosis in aneurysm	Yes; no; unknown	Supplemental
NEW	Imaging aneurysm shape type	Shape/pathology of aneurysm	Saccular; fusiform; dissecting	Supplemental—Highly Recommended
NEW	Imaging unruptured intracranial aneurysm shape follow-up	Shape of aneurysm during follow-up (irrespective of size) for each unruptured intracranial aneurysm	Constant; change in shape	Exploratory
NEW	Imaging unruptured intracranial aneurysm morphology type	Morphology type of aneurysm for each unruptured intracranial aneurysm	A: regular; B: bleb; C: daughter-sac, multilobed aneurysm	Core
NEW	Imaging unruptured intracranial aneurysm growth indicator	Increase of aneurysm diameter $\geq$ 1 mm in any direction in comparison to last imaging	Yes; no	Supplemental—Highly Recommended
NEW	Imaging unruptured intracranial aneurysm growth largest diameter measurement	Growth of aneurysm regarding largest diameter in any direction in comparison to last imaging		Supplemental—Highly Recommended
NEW	Imaging unruptured intracranial aneurysm growth month interval	Growth of aneurysm regarding largest diameter in any direction in comparison to last imaging		Supplemental—Highly Recommended
NEW	Imaging unruptured intracranial aneurysm de novo formation indicator	De novo formation of aneurysm in comparison to last imaging	Yes; no	Supplemental—Highly Recommended

ACOM anterior communicating artery, *AICA* anterior inferior cerebellar artery, *CDE* common data element, *CTA* computed tomography angiography, *DSA* digital subtraction angiography, *ID* identification number, *MRA* magnetic resonance angiography, *PCOM* posterior communicating artery, *PICA* posterior inferior cerebellar artery, *SCA* superior cerebellar artery

Table 8 CDEs—Management

CDE ID	CDE name	Definition	Permissible value	Classification
NEW	Unruptured intracranial aneurysm initial management plan	Initial management plan for unruptured intracranial aneurysm	Observation without follow-up imaging; observation with follow-up imaging; microsurgical clipping; endovascular intervention; undetermined	Exploratory
NEW	Unruptured intracranial aneurysm reason advice observation	Reason for advice for observation of unruptured intracranial aneurysm	Patient's age; health status; risk of treatment; size of UIA; location of UIA; protocol; other	Exploratory
NEW	Unruptured intracranial aneurysm reason advice treatment	Reason for advice for treatment of unruptured intracranial aneurysm	Patient's age; health status; risk of rupture; size of UIA; location of UIA; aneurysm growth on serial imaging; protocol; other;	Exploratory
NEW	Unruptured intracranial aneurysm patient following advice	Patient following advice	Yes; no	Exploratory
NEW	PHASES aneurysm risk score	PHASES aneurysm risk score		Supplemental
NEW	Unruptured intracranial aneurysm treatment score	Advice for treatment or observation of unruptured intracranial aneurysm		Supplemental

CDE common data element, *ID* identification number, *UIA* unruptured intracranial aneurysm

advanced imaging modalities in the setting of UIAs including their standardized measurement and morphological analysis.

Conclusions

We defined and categorized a total of 91 CDEs, of which 71 were novel for UIAs. These CDEs on UIAs could serve as a basis to standardize future studies and thereby help to harmonize data across studies. However, the CDEs remain to be validated, adapted, and updated in the future based on novel data for optimizing already existing CDEs and for establishing new CDEs.

Author details
[1] Department of Neurosurgery, University Hospital Mannheim, University of Heidelberg, Mannheim, Germany. [2] Brain Center Rudolph Magnus, Department of Neurology and Neurosurgery, and the Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, Utrecht, The Netherlands. [3] Centre for Clinical Brain Sciences, University of Edinburgh, Chancellor's Building, Edinburgh, UK. [4] Department of Neurosurgery, Kuopio University Hospital, Kuopio, Finland. [5] Department of Neurosurgery, University of Iowa Carver College of Medicine, Iowa City, IA, USA. [6] Department of Clinical Neurosciences, University of Helsinki, Helsinki, Finland. [7] Department of Neurosurgery, Hofstra Northwell School of Medicine, and Northwell Health, Lenox-Hill Hospital, New York, NY, USA. [8] Departments of Neurosurgery and Radiology, Columbia University Medical Center, New York, NY, USA. [9] Department of Neurological Surgery, Nippon Medical School, Bunkyo-ku, Tokyo, Japan. [10] Brain Center Rudolf Magnus, Department of Neurology and Neurosurgery and Center of Excellence for Rehabilitation Medicine, University Medical Center Utrecht, Utrecht, The Netherlands.

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UIA and SAH Working Group Members

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National Library of Medicine CDE Team
Liz Amos, MLIS, National Information Center on Health Services Research and Health Care Technology, National Library of Medicine; Christophe Ludet, MS, National Library of Medicine, Bethesda, MD.

NINDS CDE Team
Claudia Moy, PhD, NINDS, Bethesda, MD; Joanne Odenkirchen, MPH, NINDS, Bethesda, MD; Sherita Ala'i, MS, The Emmes Corporation, Rockville, MD; Joy Esterlitz, MS, The Emmes Corporation, Rockville, MD; Kristen Joseph, MA, The Emmes Corporation, Rockville, MD; Muniza Sheikh, MS, MBA, The Emmes Corporation, Rockville, MD.

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