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Standard Preanalytical Coding for Biospecimens: Review and Implementation of the Sample PREanalytical Code (SPREC)

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The first version of the Standard PREanalytical Code (SPREC) was developed in 2009 by the International Society for Biological and Environmental Repositories (ISBER) Biospecimen Science Working Group to facilitate documentation and communication of the most important preanalytical quality parameters of different types of biospecimens used for research. This same Working Group has now updated the SPREC to version 2.0, presented here, so that it contains more options to allow for recent technological developments. Existing elements have been fine tuned. An interface to the Biospecimen Reporting for Improved Study Quality (BRISQ) has been defined, and informatics solutions for SPREC implementation have been developed. A glossary with SPREC-related definitions has also been added.

Introduction

The SPREC (Standard PREanalytical Code) was developed in 2009 to provide a comprehensive and easy-to-implement tool to document the *in vitro* preanalytical (collection, processing and storage) details of biospecimens.[1] The objective of the SPREC is to facilitate annotation of biospecimens with preanalytical factors that fulfill two criteria: (a) their variation is known or highly suspected to impact the results of downstream analyses, and (b) they are within the control of the biobank and thus can be anticipated and standardized in standard operating procedures (SOPs).

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Table 1. Preanalytical Variables Included in SPREC (7-element long SPREC), Version SPREC 2.0, Applied to Fluid Samples

Type of sample	
Ascites fluid	ASC
Amniotic fluid	**AMN**
Bronchoalveolar lavage	**BAL**
Blood (whole)	**BLD**
Bone marrow aspirate	**BMA**
Breast milk	**BMK**
Buccal cells	**BUC**
Unficolled buffy coat, viable	**BUF**
Unficolled buffy coat, nonviable	BFF
Ficoll mononuclear cells, viable	**CEL**
Fresh cells from nonblood specimen type	**CEN**
Cells from nonblood specimen type (e.g., ascites, amniotic), viable	**CLN**
Cord blood	**CRD**
Cerebrospinal fluid	**CSF**
Dried whole blood (e.g., Guthrie cards)	**DWB**
Nasal washing	**NAS**
Ficoll mononuclear cells, nonviable	**PEL**
Cells from non blood specimen type (e.g., ascites, amniotic), nonviable	**PEN**
Pleural fluid	**PFL**
Plasma, single spun	**PL1**
Plasma, double spun	**PL2**
Red blood cells	RBC
Saliva	**SAL**
Semen	**SEM**
Serum	**SER**
Sputum	**SPT**
Stool	**STL**
Synovial fluid	SYN
Tears	**TER**
24 h urine	U24
Urine, random (''spot'')	**URN**
Urine, first morning	URM
Urine, timed	URT
Other	ZZZ
Type of primary container	
Acid citrate dextrose	**ACD**
Additives	ADD
Serum tube without clot activator	CAT
Citrate phosphate dextrose	**CPD**
Cell Preparation Tube®	CPT
EDTA and gel	EDG
Lithium heparin	**HEP**
Hirudin	HIR
Lithium heparin and gel	**LHG**
Oragene collection container *or equivalent*	**ORG**
PAXgene® blood RNA+	**PAX**
Potassium EDTA	**PED**
Polyethylene tube sterile	PET
S8820 protease inhibitor tablets *or equivalent*	**PI1**
Protease inhibitors	PIX
Polypropylene tube sterile	PPS
PAXgene® blood DNA	PXD
PAXgene® bone marrow RNA	PXR
Sodium citrate	**SCI**
Sodium EDTA	**SED**
Sodium heparin	SHP
Sodium fluoride/potassium oxalate	**SPO**
Serum separator tube with clot activator	**SST**
Tempus® tube	**TEM**
Trace elements tube	TRC
Unknown	XXX
Other	ZZZ
Pre-centrifugation (delay between collection and processing)	
RT*	< 2 h A
2°C–10°C	< 2 h B
RT	2–4 h C
2°C–10°C	2–4 h D
RT	4–8 h E
2°C–10°C	4–8 h F
RT	8–12 h G
2°C–10°C	8–12 h H
RT	12–24 h I
2°C–10°C	12–24 h J
RT	24–48 h K
2°C–10°C	24–48 h L
RT	> 48 h M
2°C–10°C	> 48 h N
35°C–38°C	< 2 h O
Unknown	X
Other	Z
Centrifugation	
RT 10–15 min	< 3000 *g* no braking A
RT 10–15 min	< 3000 *g* with braking B
2°C–10 °C 10–15 min	< 3000 *g* no braking C
2°C–10 °C 10–15 min	< 3000 *g* with braking D
RT 10–15 min	3000–6000 *g* with braking E
2°C–10°C 10–15 min	3000 *g* to 6000 *g* with braking F
RT 10–15 min	6000 *g* to 10000 *g* with braking G
2°C–10 °C 10–15 min	6000 *g* to 10000 *g* with braking H
RT 10–15 min	> 10000 *g* with braking I
2°C–10 °C 10–15 min	> 10000 *g* with braking J
RT 30 min	< 1000 *g* no braking M
No centrifugation	N
Unknown	X
Other	Z
Second centrifugation	
RT 10–15 min	< 3000 *g* no braking A
RT 10–15 min	< 3000 *g* with braking B
2°C–10°C 10–15 min	< 3000 *g* no braking C
2°C–10°C 10–15 min	< 3000 *g* with braking D
RT 10–15 min	3000–6000 *g* with braking E
2°C–10°C 10–15 min	3000–6000 *g* with braking F
RT 10–15 min	6000–10,000 *g* with braking G
2°C–10°C 10–15 min	6000–10,000 *g* with braking H
RT 10–15 min	> 10,000 *g* with braking I
2°C–10°C 10–15 min	> 10,000 *g* with braking J
No centrifugation	N
Unknown	X
Other	Z
Post-centrifugation delay	
< 1 h 2°C–10°C	A
< 1 h RT	B
1 to 2 h 2°C–10°C	C

(*continued*)

(*continued*)

Table 1. (Continued)

Post-centrifugation delay (Cont.)		
1 to 2 h 2°C–10°C		C
1 to 2 h RT		D
2 to 8 h 2°C–10°C		E
2 to 8 h RT		F
8 to 24 h 2°C–10°C		G
8 to 24 h RT		H
>24 h 2°C–10°C		I
>24 h RT		J
Not applicable		N
Unknown		X
Other		Z
Long-term storage		
PP tube 0.5- to 2 mL**	(−85)°C–(−60)°C	A
PP tube 0.5- to 2 mL	(−35)°C–(−18)°C	B
PP tube 0.5- to 2 mL	<-135°C	V
Cryotube 1- to 2 mL	LN***	C
Cryotube 1- to 2 mL	(−85)°C–(−60) °C	D
Cryotube 1- to 2-mL	Programmable freezing to <-135°C	E
Plastic cryo straw	LN***	F
Straw	(−85)°C–(−60)°C	G
Straw	(−35)°C–(−18)°C	H
Straw	Programmable freezing to <-135°C	I
PP tube ≥5 mL	(−85)°C–(−60)°C	J
PP tube ≥5 mL	(−35)°C–(−18)°C	K
Microplate	(−85)°C–(−60)°C	L
Microplate	(−35)°C–(−18)°C	M
Cryotube 1- to 2 mL	LN*** after temporary (−85)°C–(−60)°C	N
Plastic cryo straw	LN*** after temporary (−85)°C–(−60)°C	O
Paraffin block	RT or 2°C – 10°C	P
Bag	LN***	Q
Dry technology medium	RT	R
PP tube 40- to 500 µL	(−85)°C–(−60)°C	S
PP tube 40- to 500 µL	(−35)°C–(−18)°C	T
PP tube 40- to 500 µL	<-135°C	W
Original primary container	(−35)°C–(−18)°C or (−85)°C–(−60)°C	Y
Unknown		X
Other		Z

New elements are screened. Codes in **bold** come from the Laboratory Data Management System (LDMS).

*RT, room temperature: 18°C–28°C; **PP, polypropylene; ***LN, liquid nitrogen, referring to either vapor- or liquid-phase (this information being documented in the biobank's SOPs)

Volumes refer to container size.

The original SPREC is applicable to animal biospecimens, and more specifically to mammals. SPREC development in botanical collections and storage has also been explored.[2]

Since then and as originally anticipated, new technologies have been developed for specimen collection (e.g., new anticoagulants), processing (e.g., new tissue stabilization methods), and storage (e.g., new dry, room temperature storage media) necessitating an update of the original codes. Furthermore, with the implementation of SPREC version 1.0 in different biobanks, feedback has been received and suggestions on possible improvements considered. We are aware of at least thirteen biobanks or biobank networks in the United States, Europe, Korea, and Australia,[3] and of at least three commercial biobank LIMS who have already implemented the SPREC (personal communications). The SPREC has been incorporated in the "Minimum data set for sharing biobank samples, information, and data" (MIABIS), developed by the Biobanking and Biomolecular Resources Research Infrastructure Sweden (BBMRI.se)[4] and is also being implemented as a national standard both for healthcare and research in BBMRI.se (personal communication). An application programming interface (API) module has been developed that allows SPREC to be defined from sample collection and processing protocols, submitted to the Molecular Methods database (www.molmeth.org) that is supported by BBMRI.[5] Furthermore, SPREC is mentioned in the College of American Pathologists (CAP) biobank accreditation checklist, which is being tested in pilot audits (personal communication). Currently, the application of SPREC to stem cell biobanks is being evaluated by Demiroglu and colleagues at the University Medical Center in Göttingen, Germany (manuscript in preparation). Thus, this new version 2.0 has been developed, and is expected to be more comprehensive and easier to implement.

SPREC Version 2.0

In updating SPREC 1.0, and for the sake of continuity, no significant changes to codes were made, while new options have been added as detailed in Tables 1 and 2. The new options in SPREC 2.0 include the following:

Fluid samples

Sample types. Dried whole blood (e.g., Guthrie cards) and red blood cell fraction were added. A distinction was made between random, timed, and first morning urine specimen.

Types of primary containers. Sodium-heparin collection tube, EDTA, and heparin collection tubes with a gel separation plug and cell preparation tubes (CPT®) were added. A distinction was made between serum separation tubes with silica clot activator and tubes without additive. No distinction is now made between evacuated (Vacutainer®-type) and nonevacuated (Monovette®-type) collection tubes. Polyethylene containers (often used for urine collection) and additives (often used in urine collection) were added.

Centrifugation conditions. Initial centrifugation conditions of 30 min at room temperature (RT) with a relative G-force <1000 *g* and without braking used (most appropriate for density centrifugation and isolation of mononuclear cells) were added. For all the centrifugation options, a 10-min centrifugation time was replaced by 10–15 min to provide more flexibility. A "not applicable" option in the post-centrifugation element was added.

Storage conditions. Long-term storage options were included for liquid nitrogen preceded by temporary −80°C storage (in either cryotubes or straws). The temperature options for paraffin blocs were revised from "RT" only to "RT or 2°C–10°C". Other new storage options include a dry technology medium at RT, bag storage, original primary container, and tubes from 40–500 µL sizes. Storage at refrigerated temperatures has been harmonized throughout the SPREC and corresponds to 2°C–10°C.

Table 2. Preanalytical Variables Included in the SPREC (7-element long SPREC), Version SPREC 2.0, Applied to Solid Samples

Type of sample	
Fresh cells from non blood specimen type (e.g., biopsy)	**CEN**
Cells from non blood specimen type (e.g., dissociated tissue), viable	**CLN**
Cells from fine needle aspirate	FNA
Hair	**HAR**
Cells from laser capture microdissected tissue	LCM
Cells from non blood specimen type (e.g., dissociated tissue), nonviable	**PEN**
Placenta	**PLC**
Solid tissue	**TIS**
Disrupted tissue, non-viable	TCM
Other	ZZZ

Type of collection	
Autopsy < 6 h postmortem	A06
Autopsy 6–12 h postmortem	A12
Autopsy 12–24 h postmortem	A24
Autopsy 24–48 h postmortem	A48
Autopsy 48–72 h postmortem	A72
Biopsy in culture media	BCM
Biopsy	**BPS**
Biopsy in normal saline or phosphate buffered saline	BSL
Biopsy in tissue low temperature transport media	BTM
Fine needle aspirate	FNA
Punction	PUN
Surgical excision in culture media	SCM
Surgical excision	SRG
Surgical excision in normal saline or phosphate buffered saline	SSL
Surgical excision in tissue low temperature transport media	STM
Surgical excision in vacuum container	VAC
Swab	**SWB**
Other	ZZZ

Warm ischemia time	
< 2 min	A
2–10 min	B
10–20 min	C
20–30 min	D
30–60 min	E
> 60 min	F
Unknown	X
Not applicable (e.g., biopsy)	N
Other	Z

Cold ischemia time	
< 2 min	A
2–10 min	B
10–20 min	C
20–30 min	D
30–60 min	E
> 60 min	F
Unknown	X
Not applicable (e.g., autopsy)	N
Other	Z

(*continued*)

Table 2. (Continued)

Fixation/stabilization type	
Non-aldehyde with acetic acid	ACA
Aldehyde-based	ALD
Allprotect® tissue reagent	ALL
Alcohol-based	ETH
Nonbuffered formalin	FOR
Heat stabilization	HST
Snap freezing	**SNP**
Non-aldehyde based without acetic acid	NAA
Neutral buffered formalin	NBF
Optimum cutting temperature medium	**OCT**
PAXgene® tissue	PXT
RNA Later®	**RNL**
Unknown	XXX
Other	ZZZ

Fixation time	
< 15 min	A
15 min–1 h	B
1–4 h	C
4–8 h	D
8–24 h	E
24–48 h	F
48–72 h	G
Not applicable	N
Unknown	X
Other	Z

Long-term storage		
PP tube 0.5–2 mL**	(−85)°C–(−60)°C	A
PP tube 0.5–2 mL	(−35)°C–(−18)°C	B
PP tube 0.5–2 mL	<-135°C	V
Cryotube 1–2 mL	Liquid nitrogen***	C
Cryotube 1–2 mL	(−85)°C–(−60)°C	D
Cryotube 1–2 mL	Programmable freezing to <-135°C	E
Plastic cryostraw	Liquid nitrogen	F
Straw	(−85)°C–(−60)°C	G
Straw	(−35)°C–(−18)°C	H
Straw	Programmable freezing to <-135°C	I
PP tube ≥5 mL	(−85)°C–(−60)°C	J
PP tube ≥5 mL	(−35)°C–(−18)°C	K
Microplate	(−85)°C–(−60)°C	L
Microplate	(−35)°C–(−18)°C	M
Cryotube 1–2 mL	LN*** after temporary (−85)°C–(−60)°C	N
Straw	LN*** after temporary (−85)°C–(−60)°C	O
Paraffin block	RT or 2°C − 10°C	P
Bag	LN***	Q
Dry technology medium	RT	R
PP tube 40–500 µL	(−85)°C–(−60)°C	S
PP tube 40–500 µL	(−35)°C–(−18)°C	T
PP tube 40–500 µL	<-135 ° C	W
Original primary container	(−35)-(−18)°C or (−85)-(−60) °C	Y
Unknown		X
Other		Z

New elements are screened. Codes in **bold** come from the Laboratory Data Management System (LDMS).

*RT, room temperature: 18°C–28°C; **PP, polypropylene; ***Liquid nitrogen refers to either vapor or liquid phase (this information being documented in the biobank's SOPs)

Volumes refer to container size.

Solid samples

Sample types. Placenta was added as a new sample type. The abbreviation LCM appeared twice in the sample type element in version 1.0. In version 2.0, LCM corresponds to cells from laser capture microdissected tissue, while TCM corresponds to cells from mechanically disrupted tissue.

For biopsies and surgical excisions, options for collection (and subsequent transport) in either saline, culture media, or low-temperature transport media (e.g., AQIX, Hyperthermosol, Unisol, Thermo-ROS) or in vacuum containers were added.

"Fixation" type became "fixation/stabilization" type and now includes heat stabilization, PAXgene® tissue fixation, and Allprotect® tissue fixation/stabilization options.

A "not applicable" option was added in the Fixation time element.

Support Tools for Implementation of SPREC Version 2.0

The integration of SPREC into biobank databases generally requires the inclusion of SPREC drop-lists among the "tables" in the software. This is relatively easy with customized software, but the supplier would need to make a customized development for off-the-shelf software. Two tools have been developed in order to facilitate SPREC implementation and interfacing with either customized or off-the-shelf biobank software.

A default SPREC can be set per sample type according to the SOPs of the collection project. Thus, only deviations from the SOP SPREC need to be documented. These can be highlighted, making any deviation from pre-defined sample quality or any nonconforming in processing directly visible. However, active generation of the SPREC for each individual sample is to be preferred as it enforces traceability.

Although the use of the SPREC requires an additional initial investment of time, it is expected that this will be more than repaid by the ease and accuracy of subsequent sample search and selection.

SPRECware

The first tool (SPRECware) requires entry of each samples' SPREC elements. SPRECware[6] is an IT architecture, that is, a collection of software and communication tools that have been developed in order to foster the adoption of SPREC by biobanks and biolaboratories. Basic information concerning preanalytical processing of a given sample is selected from drop-down menus. The resulting SPREC is generated together with the corresponding barcode, and all the preanalytical data with the SPREC are stored in a local database.

One component, SPRECbase, has been recently released and is freely downloadable from http://www.sprecware.org. This software supports both coding/printing barcode labels and decoding in text of a sample's SPREC, then storing all the preanalytical data in a local database. These barcodes simplify storing and exchanging corresponding information about the samples.

In a working environment, SPRECware is intended to be connected to the laboratory/biobank information system (LIS/BIS). The required data can then be loaded from the originating biobank's LIS/BIS database and translated into the SPREC. Samples are thus labeled with both the human-readable and barcoded format. The barcode provides the receiver organization with the data documenting the specimen and can be stored in the LIS/BIS. This approach provides fully automated data transfer without manual writing or reading when the organizations exchanging specimens both use SPREC. In the case that the receiving organization has not adopted the SPREC, it is still possible to read the SPREC (e.g., by a barcode scanner) and download the explicit preanalytical data by means of an internet connection.

Since the SPREC does not encapsulate any personal data, it can be used for searches on sample availability. This possibility of a preliminary check would allow a researcher to select material with the most appropriate preanalytical characteristics for a planned experiment.[6] (Even in the case of derivatives (e.g., DNA, RNA), the SPREC information on the collected samples, from which derivatives were produced, is highly valuable.

SPRECalc

Unlike the SPRECware which requires entry of the SPREC options (A, B, X…), the second tool (SPRECalc) requires entry of the corresponding preanalytical variables themselves (temperature, time…); this tool then performs automatic calculation of the time-associated elements and generation of SPREC.

The Excel-based SPRECalc automatically calculates SPREC time-associated elements for solid and fluid samples, using the data logic depicted in Figures 1 and 2. Data entry is supported by pull-down lists (blue-colored fields in the Excel tool) to minimize inconsistent data entry. The dropdowns are based upon SPREC version 2.0 as specified in this article and are provided in the "Lists" worksheet. Time stamps have to be entered in the format dd/mm/yyyy hh:mm:ss (pink-colored fields in the Excel tool) to allow correct calculation of time spans. The format of the related columns is pre-defined.

To ensure that automatic SPREC calculation and generation can be performed, the data items in Table 3 must be either captured manually or retrieved automatically (i.e., *via* barcode scanning or RFID tagging).

Gray fields contain automatic calculations/translations, displaying either the time period (e.g., warm/cold ischemia time, fixation time), or "help" columns for identification of the applicable SPREC.

For solid samples, the fixation time can be determined in two different ways. Option 1 is designed for use with automated fixation systems (fixation start time, program type, and program start time need to be recorded). Option 2 is targeted for nonautomated fixation steps (fixation start and end time need to be entered).

With respect to option 1, the "Fixation Programs" worksheet allows the user to predefine fixation programs and their respective duration. Selection of the applicable program during data entry automatically uses the related duration to calculate the correct fixation time, provided fixation start time and program start time have been entered as well. For each sample, SPREC is then automatically displayed following the coding rules specified in this article. All of these fields are protected against changes.

The tool also contains the following quality-related features. The data entry worksheet provides its own "quality control" features, since Excel-specific error messages in the

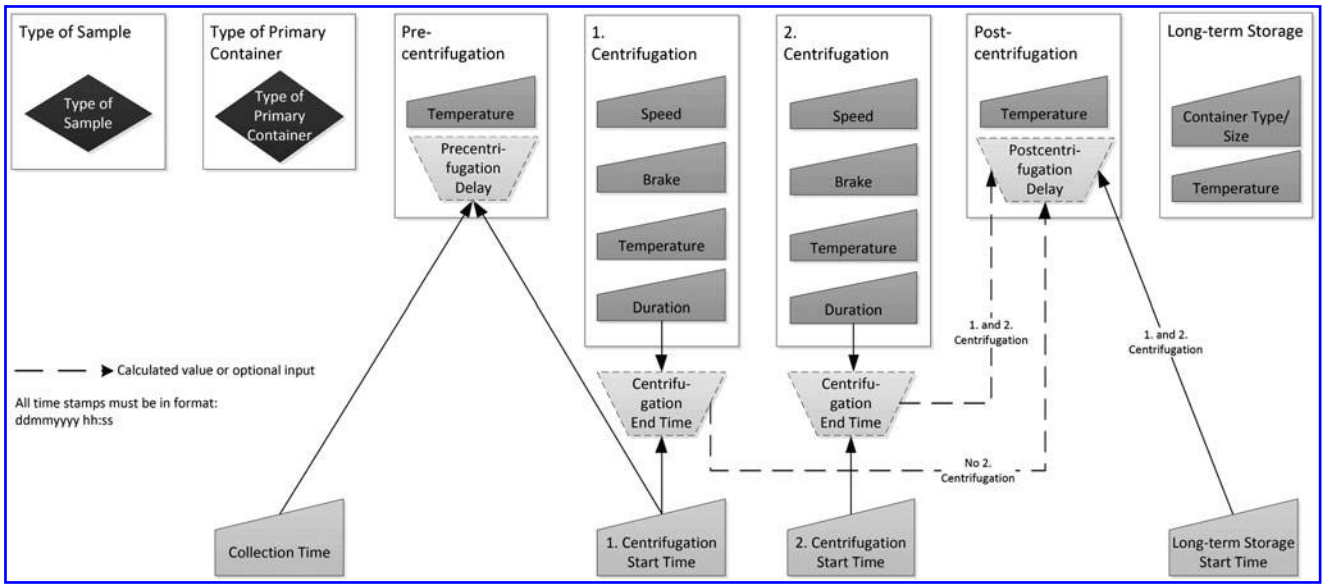


FIG. 1. The elements and their relationships needed for automated SPREC calculation for fluid samples.

calculated columns (e.g., ###### or #REF) indicate data inconsistency (e.g., the fixation start time entered is before the collection time). Systematic investigation of such errors supports quality checks to improve data quality and consistency.

Default SPRECs can be defined for each collection according to established SOPs for sample collection. Nonconformities can be detected automatically by the system and flagged in dedicated columns, with a flexible way of setting target parameters (e.g., fixation time shall be < = 24 h). Alternatively the same nonconformities can be specifically custom-programmed directly in the final SPREC columns, using the "conditional formatting" functionalities of Excel. These nonconformities should then be investigated as required by the organization's Quality Management System (QMS) as part of biobank accreditation.

In addition to columns with a "Z" option ("Other"), text columns are provided, allowing recording of more detailed information in cases where other specifications than those listed in the SPREC were applied. If a value is unknown, then "unknown" should be entered.

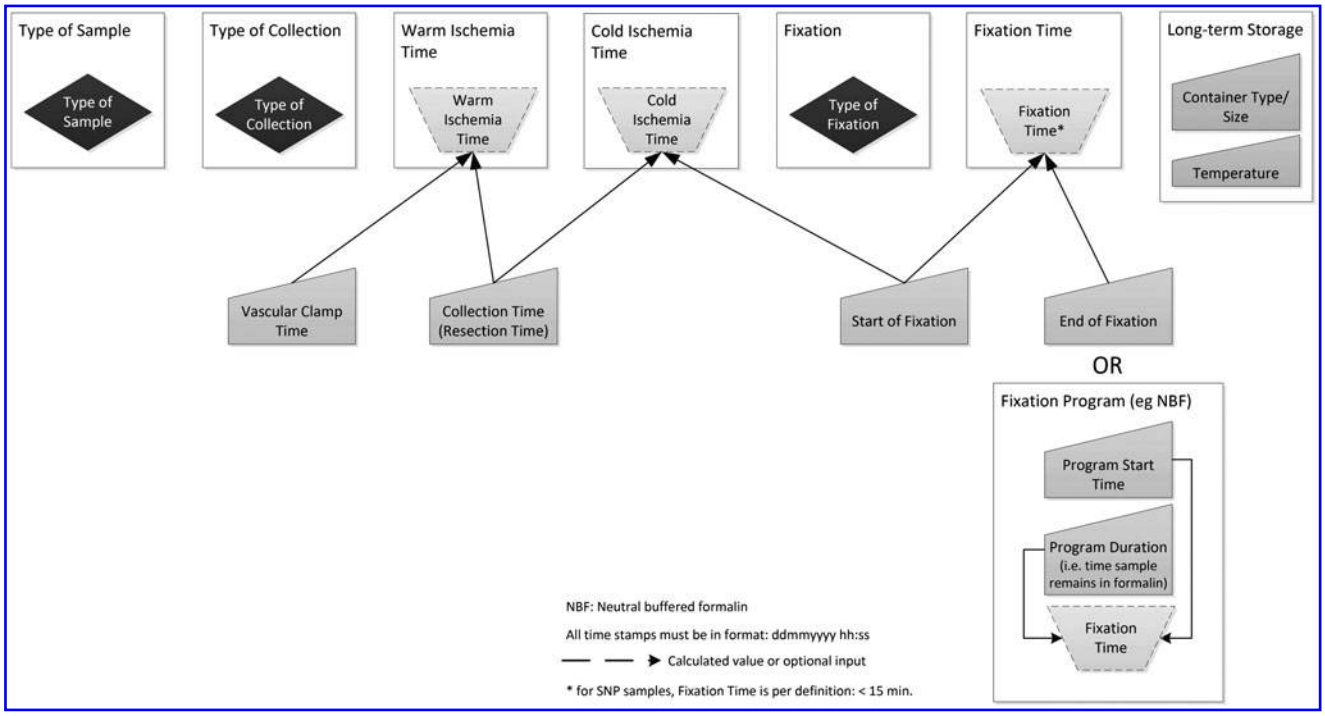


FIG. 2. The elements and their relationships needed for automated SPREC calculation for solid samples.

Table 3. Date Items for Automatic SPREC Calculation

Fluid Samples	*Solid Samples*
Type of sample	Type of sample
Type of primary sample container	Type of collection
Collection time	Vascular clamping time at surgery (denotes beginning of warm ischemia)
Time of first centrifugation start	Time of collection/Time of excision (denotes end of warm ischemia time and beginning of cold ischemia time)
Sample temperature between collection and first centrifugation	Fixation/stabilization type
First centrifugation speed	Fixation start time (denotes end of cold ischemia time for fixed tissue)
First centrifugation brake	Fixation end time (alternatively for automated processes: program start time, program type with related duration)
First centrifugation temperature	Fixation end time (alternatively for automated processes: program start time, program type with related duration)
Time of first centrifugation start[1]	Temperature of long term storage
Time of first centrifugation end (or duration of first centrifugation)	Type of container of long term storage
Second centrifugation speed	
Second centrifugation brake	
Second centrifugation temperature	
Time of second centrifugation start	
Time of second centrifugation end[2] (or duration of second centrifugation)	
Time of putting into temporary storage	
Temperature of temporary storage	
Time of putting into long term storage	
Sample Temperature between end of last centrifugation and putting into long term storage	
Temperature of long term storage	
Type of container of long term storage	

[1]Time of freezing in the case of PAXgene®.
[2]Time of last washing centrifugation in the case of viable cells.

The "Statistics" worksheet displays summary statistics about the sample collection (e.g., number and percentage of samples per code type, average, minimum, maximum and median for selected time spans) related to selected SPREC items (e.g., warm/cold ischemia time and fixation time for solid samples). This summary sheet also allows the continuous automated calculation of key performance indicators (KPI), as required by quality norms. An example is shown for the percentage of solid samples in the collection with warm ischemia times below 30 min (Fig. 3). For example, a report can be generated stating the percentage of solid samples in the collection with warm ischemia times below 30 minutes. Reports of variables of interest can be programmed as required by the user. The Excel tool is available on http://www.isber.org/SPRECtools.cfm.

Although SPRECalc is a stand-alone tool, the final SPREC can be imported into a biobank database at regular intervals. This solution provides a simple way of integrating the SPREC into custom software, since no data logic or drop-down lists need to be created. It is also possible to combine the SPREC tools described here, the SPRECalc and SPRECware, for generating and encoding SPRECs, respectively.

SPREC Interface with Reporting Recommendations

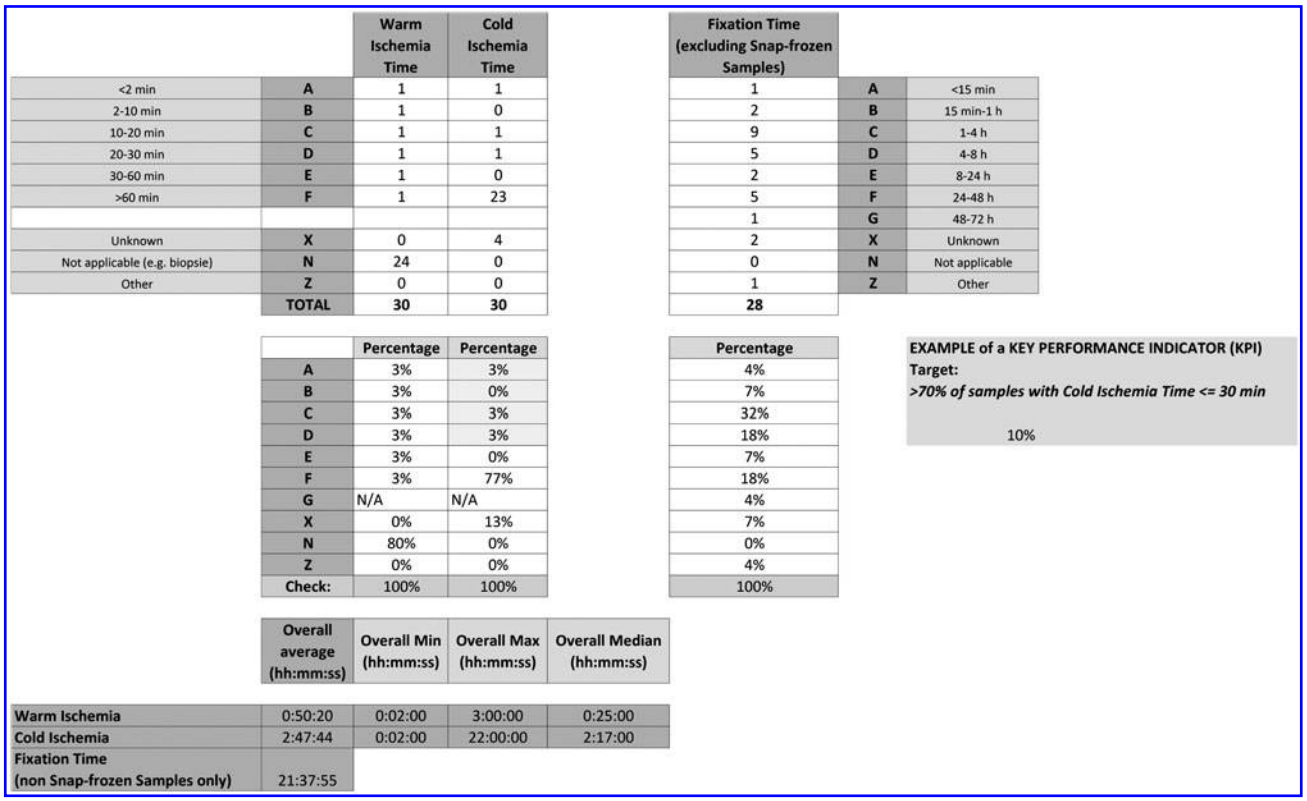
A recent publication[7] proposed reporting recommendations : Biospecimen Reporting for Improved Study Quality (BRISQ). These recommendations include the type of information that should be reported in scientific publications and regulatory submissions based on work with biospecimens. Whereas these recommendations present the different data items that should be reported, they do not provide a standardized way of reporting them. The SPREC provides this standardized format and can be efficiently used to fulfill all of the BRISQ requirements that relate to *in vitro* variables: covering the workflow between the time of specimen collection and long-term storage. Table 4 presents the interface between the BRISQ and the seven basic SPREC elements (Table 4).

Conclusion

SPREC version 2.0 includes several new options, mainly new sample types and additional storage conditions. Development of the SPREC version 2.0 was based on valuable input from many different biobanks worldwide that had previously implemented SPREC version 1.0. Furthermore, we describe readily accessible tools that facilitate implementation of SPREC in biobank databases and fulfill requirements of the BRISQ.[7]

Glossary

Additives, urine: The most common urine preservatives are boric acid, tartaric acid, or ascorbic acid. They reduce the risk of bacterial overgrowth and specimen decomposition. Preservation at room temperature ranges from 24 to 72 hours.



		Warm Ischemia Time	Cold Ischemia Time
<2 min	A	1	1
2-10 min	B	1	0
10-20 min	C	1	1
20-30 min	D	1	1
30-60 min	E	1	0
>60 min	F	1	23
Unknown	X	0	4
Not applicable (e.g. biopsie)	N	24	0
Other	Z	0	0
	TOTAL	30	30

Fixation Time (excluding Snap-frozen Samples)		
1	A	<15 min
2	B	15 min-1 h
9	C	1-4 h
5	D	4-8 h
2	E	8-24 h
5	F	24-48 h
1	G	48-72 h
2	X	Unknown
0	N	Not applicable
1	Z	Other
28		

	Percentage	Percentage
A	3%	3%
B	3%	0%
C	3%	3%
D	3%	3%
E	3%	0%
F	3%	77%
G	N/A	N/A
X	0%	13%
N	80%	0%
Z	0%	0%
Check:	100%	100%

Percentage
4%
7%
32%
18%
7%
18%
4%
7%
0%
4%
100%

EXAMPLE of a KEY PERFORMANCE INDICATOR (KPI)
Target:
>70% of samples with Cold Ischemia Time <= 30 min

10%

	Overall average (hh:mm:ss)	Overall Min (hh:mm:ss)	Overall Max (hh:mm:ss)	Overall Median (hh:mm:ss)
Warm Ischemia	0:50:20	0:02:00	3:00:00	0:25:00
Cold Ischemia	2:47:44	0:02:00	22:00:00	2:17:00
Fixation Time (non Snap-frozen Samples only)	21:37:55			

FIG. 3. Screenshot of SPRECalc statistics function.

TABLE 4. COMPARISON OF THE BRISQ AND SPREC DATA ELEMENTS

BRISQ data element	*SPREC data element*
Biospecimen type	Sample type
Anatomical site	NI [not included]
Disease status of patients	OS [out of scope]
Clinical characteristics of patients	OS
Vital state of patients	Type of collection
Clinical diagnosis of patients	OS
Pathology diagnosis	OS
Collection mechanism	Type of primary container
	Pre-centrifugation delay
	Centrifugation
	Second centrifugation
	Post-centrifugation delay
	Type of collection
	Warm ischemia time
	Cold ischemia time
Type of stabilization	Type of primary container
	Type of collection
Type of long-term preservation	Fixation/stabilization type
	Fixation time
	Long-term storage
Constitution of preservative	Fixation/stabilization type
Storage temperature	Long-term storage
Storage duration	NI
Shipping temperature	NI
Composition assessment and selection	OS

BRISQ data elements that are out of scope (OS) are *in vivo*- or pathology-related elements: These are not considered to be SPREC elements. BRISQ data elements that are not included (NI) are those that relate to events during long term storage. The SPREC covers processes until the specimens are placed in long term storage.

Buffy coat: The layer of white cells that forms between the layer of red cells and the plasma when unclotted blood is centrifuged or allowed to stand.

Cell preparation tube: Blood collection tube containing cell separation media in the form of gel and/or filter.

Cryotubes: High density polypropylene tubes manufactured to withstand ultra-low temperature conditions.

Dissociated tissue: Tissue that has undergone mechanical (e.g., scalpel) or chemical (e.g., protein digestion) separation, allowing whole cells to be retrieved.

Disrupted tissue: Tissue that has undergone mechanical (e.g., sonication, freeze-thaw) or chemical (e.g., lysis buffer) cellular disintegration.

Long-term storage: Storage of samples at their final destination temperature after possible temporary storage at conditions, imposed by technical (e.g., overnight storage of viable cells at −80°C before transfer into liquid nitrogen) or logistical (e.g., overnight storage of serum at −20°C before transfer to −80°C in central storage facility) reasons.

Pre-centrifugation delay: Time between collection and first centrifugation of the samples. In the case of PAXgene® tubes, this corresponds to the delay between blood collection and freezing of the tube (in this case, equivalent of "pre-processing" delay). In the case of no centrifugation at all, the "pre-centrifugation delay" corresponds to the delay between collection time and start of long-term storage.

Post-centrifugation delay: Time between the last centrifugation and storage of the samples. In the case of viable cells, this corresponds to the delay between the last washing

centrifugation and the time of cryopreservation. In the case of PAXgene® tubes, the "post-centrifugation delay" is not applicable. In the case of no centrifugation at all, the "post-centrifugation delay" is not applicable.

Programmable freezing: Freezing in either a programmable rate freezer or alternative solutions such as Mr Frosty.

Puncture: Surgical piercing of an anatomical tissue to obtain material for clinicopathological examination. Includes cisternal puncture, lumbar puncture, spinal puncture, sternal puncture.

Room Temperature: Defined as 18°C–28°C.

Temporary Storage: Initial-term storage in conditions different from the long-term storage conditions.

Author Disclosure Statement

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