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Microsampling for antidepressant drug analysis: Current state and perspectives

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ABSTRACT

Microsampling has emerged as a highly promising approach for the quantitative analysis of antidepressant drugs, offering key benefits in terms of minimal invasiveness, reduced blood volume requirements and suitability for decentralised and patient-centric sample collection. Historically, the clinical adoption of therapeutic drug monitoring (TDM) for antidepressants has lagged behind that for other CNS drugs, largely due to perceptions of a wide therapeutic window and moderate toxicity risk. However, growing recognition of pharmacokinetic variability, challenges in polypharmacy and evolving models of personalised medicine, now highlight the critical need for robust and adaptable analytical strategies in this field. Technologies such as dried blood spot (DBS) sampling, volumetric absorptive microsampling (VAMS), capillary- and microfluidic-generated DBS, capillary microsampling (CMS) and novel hybrid/automated platforms have been developed and validated for antidepressant quantification across diverse settings (including clinical, preclinical and forensic applications). This review provides a comprehensive analysis of the principles, methodologies and translational relevance of microsampling for antidepressants, critically summarising evidence from original research papers and key review papers. We explore technical and analytical challenges including matrix effects, haematocrit variability, sample stability and the processes underpinning quantitative bridging to conventional matrices such as plasma and serum. Major recent advances, like operator-independent volumetric devices and workflow automation, are contextualised within the broader push toward remote and home-based monitoring. Clinical validation studies, animal model research and post-mortem investigations are reviewed to illustrate the wide range and adaptability of these technologies. By highlighting both achievements and unresolved barriers, this work demonstrates how microsampling is poised to transform antidepressant TDM, research and future psychiatric pharmacotherapy.

1. Introduction

Antidepressant drugs (ADs) are therapeutic agents pivotal in current guidelines for the management of mood and anxiety disorders [1]. A plethora of different molecules, belonging to several chemical-pharmacological classes, are included in the definition of ADs, starting from the classical, first-generation tricyclic ADs (TCA—e.g., imipramine, amitriptyline) and monoamine oxidase inhibitors (MAOI—e.g., tranylcypromine); to new- or second-generation ADs (SGA): selective serotonin reuptake inhibitors (SSRIs—e.g., fluoxetine), serotonin and norepinephrine reuptake inhibitors (SNRI—e.g., venlafaxine); serotonin modulators and stimulators (SMS—e.g., vortioxetine); serotonin antagonists and reuptake inhibitors (SARI—e.g., trazodone); noradrenergic and selective serotonergic antidepressants (NaSSAs—e.g., mirtazapine); norepinephrine reuptake inhibitors (NRIs—e.g., reboxetine); serotonin, norepinephrine and dopamine reuptake inhibitors (SNDRIs—e.g., nefazodone); melatonergic agonists and selective serotonergic antagonists (MASSAs—e.g., agomelatine); and norepinephrine and dopamine reuptake inhibitors (NDRIs—e.g., bupropion). The chemical structures of the most representative drugs of each class are shown in Fig. 1.

Despite this wealth of therapeutically applied ADs, therapeutic drug monitoring (TDM) for this class has not been widely established in daily clinical practice [2–5]. By contrast, the clinical benefits of TDM have long been established and accepted for antipsychotic drugs, supporting routine use in psychiatric pharmacotherapy [6–8]. Historic perceptions

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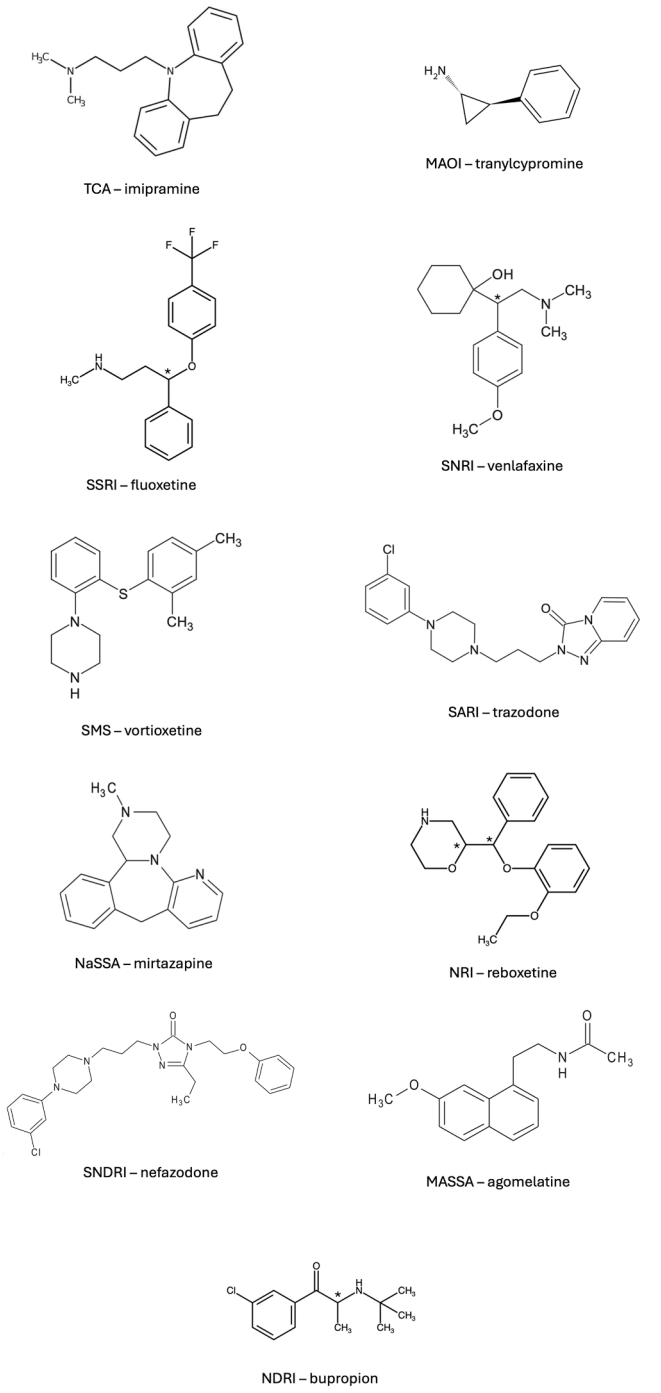

Fig. 1. Chemical structures of representative drugs from the most important antidepressant classes.

of broad therapeutic windows and moderate interindividual variability limited the perceived need for TDM of patients treated with ADs. Modern psychiatric care, however, increasingly recognises the need for analytical methods and tools that reliably accommodate polypharmacy, variability in metabolism and demands for personalised care (thereby reviving interest in robust and patient-aligned TDM) [1,9].

Microsampling, defined as the collection of biofluids in microliter volumes (typically <100 µL), offers a dual methodological and organisational solution for key challenges in psychiatric pharmacology. Originally designed to reduce invasiveness in neonatal and animal studies, microsampling technologies such as dried blood spot (DBS) sampling, volumetric absorptive microsampling (VAMS) and capillary microsampling (CMS) are now being adopted for decentralised and home-based workflows [10–13]. These advances have been accelerated by digital health transitions and the broader ambition to minimise burden and enhance analytical data quality [14].

While central nervous system (CNS) drug TDM and microsampling are well established in antipsychotic and antiepileptic therapy, application to ADs is relatively recent and less well described [4,15]. Here, we provide a concept-driven overview exploring how technical innovations, workflow design and context converge to determine the role of microsampling in modern ADs analysis.

This review focus is on advanced microsampling, i.e., volumetric formats (VAMS; microfluidic/volumetric DBS and CMS) specifically applied to ADs in clinical, preclinical and forensic contexts. Classical, non-volumetric DBS and reports on other drug classes are cited only when directly informative to AD-specific device features or workflow decisions.

2. Microsampling technologies in antidepressant drug analysis

2.1. Rationale, evolution and foundations

Microsampling evolution stems from the need to minimise patient burden, enable remote and serial sampling and maintain high data quality when repeated venipuncture is impractical [3,16]. Over the last decade, innovations in dried matrix spots, volumetric devices and microfluidic systems have responded to logistic, ethical and analytical demands, particularly in multi-site studies, paediatrics and telemedicine [5,6]. Foundations of microsampling span from early dried-spot cards to volumetric and microfluidic devices designed to control volume and mitigate haematocrit/operator effects, enabling reliable decentralised sampling.

2.2. The technology landscape: devices and methodologies

From a methodological standpoint, device choice dictates volume control, drying/storage requirements and pretreatment routes (e.g., whole-spot vs punch extraction; off-line extraction vs direct desorption). These factors in turn influence precision, recovery and the ease of bridging to plasma/serum.

DBS, the archetype of simplicity and analyte stability, forms a foundation for the microsampling field.

Filter paper cards (e.g., Whatman 903, FTA DMPK) enable simple collection and robust sample storage. Yet, awareness of volumetric inaccuracy and haematocrit effects (as source of inter-sample variability) has driven innovation toward volumetric technologies [5,17].

VAMS (Mitra™) and capillary- and microfluidic-generated DBS (e.g., HemaPEN™, HemaXis™) have addressed these limitations by absorbing a defined microvolume of blood, substantially reducing matrix and operator variability [18,19]. These are now pivotal in both decentralised clinical trials and population screening, due to operator independence and reproducibility (Fig. 2).

CMS and thin polymer film samplers further broaden the toolkit, especially in animal studies and paediatrics, where serial, small volumes and minimal invasiveness are mandatory [20,21]. Recent years have also seen automated and hybridised approaches, such as parallel artificial liquid membrane extraction-DBS (PALME-DBS) and online desorption, which further streamline and scale up laboratory workflows [15,22,23]. Overall, DBS offers simplicity and storability but is volume-dependent and sensitive to haematocrit-driven bias effects. VAMS provides a defined micro-volume, reducing haematocrit- and operator-related variability while remaining user-friendly for decentralised sampling. CMS yields liquid micro-aliquots enabling serial low-volume sampling (not necessarily dried), particularly useful in preclinical and paediatric settings. These complementary features guide device selection according to context and downstream analytical needs.

For example, VAMS or microfluidic DBS can support decentralised

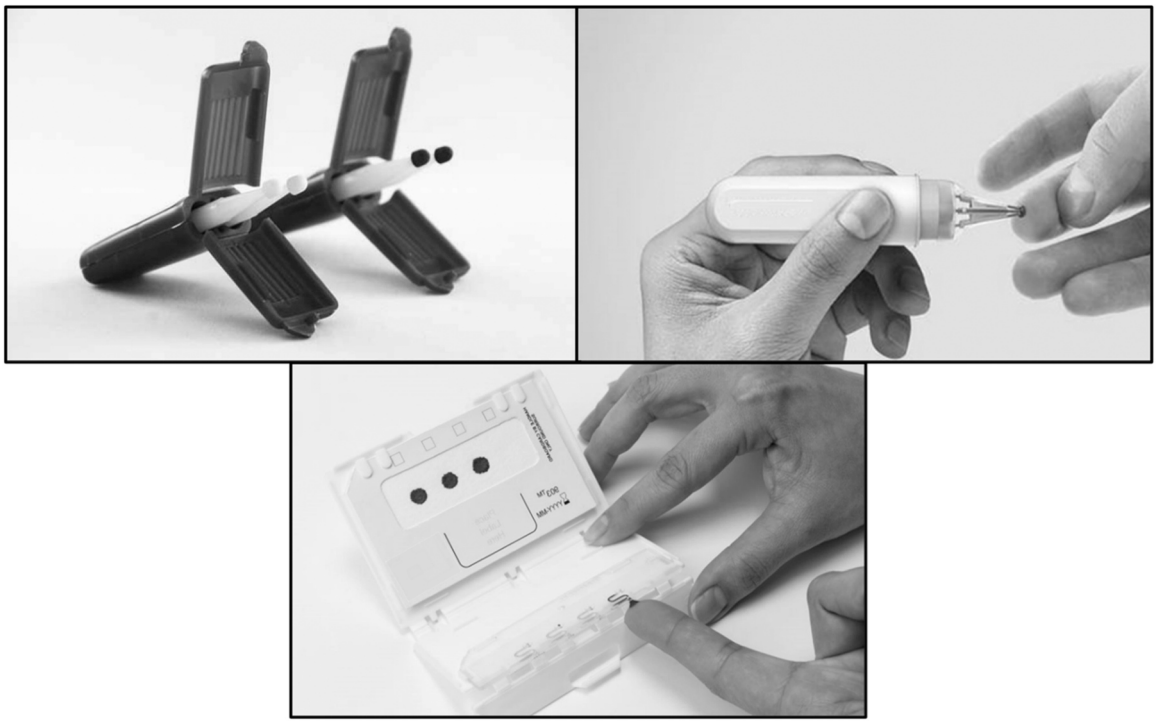

Fig. 2. Schematic representation of the main volumetric microsampling technologies exploited for antidepressant drugs analysis: (a) volumetric absorptive microsampling, (b) capillary-generated dried blood spots and c) microfluidic-generated dried blood spots.

TDM of antidepressants in scenarios where self-sampling and postal shipment of dried microsamples may be implemented to reduce in-clinic blood draws, whereas CMS is more suitable for preclinical pharmacokinetic/toxicokinetic studies of tricyclic antidepressants that require dense sampling schedules and liquid micro-aliquots. Dried DBS formats, in turn, are especially valuable in forensic and post-mortem applications owing to their excellent storability.

Patient- and user-related features are also important. Capillary finger-prick microsampling is minimally invasive, but patient safety requires appropriate lancet disposal, clear self-collection instructions and proper labelling and transport of biohazardous materials. For DBS cards (including microfluidic/volumetric DBS), samples should be fully dried, collected with adequate finger-stick hygiene and physically protected after sampling. For VAMS, over-filling should be avoided and device-specific drying instructions followed. For liquid CMS, samples should be labelled immediately and stored in appropriate containers, with cold-chain management when required. A comparative overview of AD-focused experimental studies is assembled in Table 1, which summarises how these generally applicable devices and workflows (Figs. 2 and 3) have been used for quantitative antidepressant analysis, although they are by no means antidepressant-specific sampling devices.

Regarding the biological matrices themselves, all techniques described are validated by the respective manufacturers on blood. However, in line of principle all of them could be also used to microsample any other reasonably fluid matrix (such as plasma, serum, urine, oral fluid, sweat, etc.), possibly applying some procedural adjustment and precautions. It goes without saying that in those cases the whole procedure and device suitability should be validated according to international guidelines.

2.3. Clinical, preclinical and forensic applications

Choices among microsampling technologies are context dependent.

For outpatient/home TDM of SSRIs/SNRIs, volumetric devices (e.g., VAMS or microfluidic DBS) support self-sampling with robust volume control and subsequent bridging to plasma where needed [16,24,25]. In preclinical PK/TK of TCAs, CMS enables serial low-volume sampling without repeated venipuncture, improving animal welfare and temporal resolution [19,20]. Forensic and post-mortem research, in turn, values the stability and storability conferred by dried devices [26,27]. More details can be found in Table 1.

3. Analytical and methodological considerations

3.1. Validation of microsampling methods

Validation for microsampling in AD analysis examines sensitivity, accuracy, selectivity, matrix effect and stability, thus keeping application and sample type in view [16,17,28–30].

Calibration and response linearity are core elements of bioanalytical validation; device/matrix choices may affect extraction efficiency and repeatability. Detailed regulatory frameworks exist to guide acceptance criteria [31].

Device and matrix interplay shape precision and trueness, with haematocrit and spot size addressed by volumetric controls, corrections or whole-spot analyses [18,32]. Selectivity is governed by the analytical method (chromatography/spectrometry) and the sample pretreatment strategy, whereas the sampling device primarily influences volume control, haematocrit sensitivity, operator dependence and storage.

3.2. Stability and storage

Most ADs show robust stability in dried microsamples for weeks to months, even at ambient temperature, however caution remains for unstable metabolites (especially *N*-oxides) for which support material, drying and storage protocols must be tailored [25,34].

3.3. Matrix comparison and bridging

A critical requirement for method acceptance is whether microsampling recapitulates concentrations obtained from plasma or serum. Numerous direct comparisons show that for most ADs, microsample and

Table 1
Comparative overview of the main experimental studies aimed at antidepressant analysis by exploiting microsampling.

Analyte(s)	Matrix	Microsampling technology	Sample volume	Sample treatment	Application	Analytical setup	Key findings	Bridging/ comparison	Notes	Ref.
Fluoxetine, Norfluoxetine, Sertraline, *N*-desmethylsertraline	Capillary blood	Volumetric DBS	2.74 µL x4	MeOH extraction, ultrasound, centrifuge	TDM	LC-MS/MS	Linear, recovery > 81 %, RSD < 12 %, stable, no Hct effect	Strong plasma correlation, convert with ratio	EMA/FDA validated; self-sampling	[17]
Sertraline, Fluoxetine, Citalopram, Vortioxetine, Norsertraline, Norfluoxetine, *N*-desmethylcitalopram, *N,N*-didesmethylcitalopram	Capillary blood; oral fluid	VAMS	20 µL	MeOH extraction, ultrasound, MEPS	TDM	HPLC-UV/ FL	Linear, recovery > 84 %, RSD < 9 %, stable	Correlates with plasma/oral fluid	Real patient validation	[33]
Fluoxetine, Norfluoxetine	Capillary blood	DBS	50 µL	MeOH/ACN extraction, centrifuge	TDM	LC-MS/MS	Linear 10–750 ng/mL, recovery 92 %, RSD < 10 %, stable 7d	Plasma/DBS ratio: 0.71, 0.68	30 patients; min Hct effect	[16]
Fluoxetine, Norfluoxetine, proprietary drugs	Rat blood	Capillary microsampling	8 µL	Dilution, P/P	Rat PK	LC-MS/MS	CMS equal to std blood for FLX/GLP; some site differences	PK equivalence if same site	Preclinical only	[19]
Sertraline, Desmethylsertraline	Capillary blood	DBS	20 µL	MeOH extraction, vortex, ultrasound	TDM	HPLC-UV	Linear 20–1000 ng/mL, rec > 85 %, stable	Plasma/DBS factor provided	54 clinical paired samples	[30]
Fluoxetine, Norfluoxetine, Reboxetine, Paroxetine	Capillary blood	Volumetric DBS	10 µL	Extraction, derivatisation	TDM; PK; tox	GC-NICI-MS/MS	Linear, LOD 20 pg/mL, rec 61–90 %, stable 30d	Matches plasma PK from literature	Also: antipsychotics	[27]
Amitriptyline, Nortriptyline, Clomipramine, Desmethylclomipramine, Venlafaxine, *O*-desmethylvenlafaxine	Capillary blood	DBS	20–100 µL	ACN/MeOH extraction	TDM	LC-MS/MS	Linear, limited Hct effect, conversion to plasma	High correlation DBS-plasma	162 paired clinical samples	[23]
Venlafaxine, *O*-desmethylvenlafaxine	Capillary blood	DBS	40–80 µL	ACN/MeOH, vortex extraction	TDM	LC-MS/MS	Linear, no Hct effect, rec 78–92 %, stable	Plasma/DBS r^2> 0.98, conversion given	No clinical samples	[40]
Amitriptyline	Capillary blood, oral fluid	DBS; dried saliva spot	10 µL	Direct SERS	Toxicology	SERS	LOD 95 ppb, linear, fast, coverage	No plasma comparison	First SERS amitriptyline DBS	[36]
Amitriptyline, Citalopram, Imipramine, Benzodiazepine, Hypnotics	Post-mortem whole blood	DBS	50 µL	Microwave extraction, SPE	Forensic/ toxicology	CE-MS	LOQ 5–49 ng/mL, rec 85–105 %, precise, stable	Used paired post-mortem, punch calculated	Includes non-AD	[38]
Amitriptyline, Antipsychotics, NSAIDs	Capillary blood	DBS	5–20 µL	PALME/MeOH extraction	Proof/ validation	UHPLC-UV-MS/MS	Rec 63–85 %, linear, RSD < 14 %, EMA OK	Not compared plasma; PALME recovers analytes	First PALME with DBS	[21]
Amitriptyline, Nortriptyline, Imipramine, Desipramine, Clomipramine, Desmethylclomipramine	Capillary blood	DBS	50 µL	ACN/MeOH extraction	TDM	LC-MS/MS	Linear 20–500 µg/L, rec > 80 %, bias at Hct< 0.3	Plasma-DBS r^2~0.9; correction needed	Clinical validation	[31]
Amitriptyline, Imipramine, Antipsychotics, Beta-blockers, Ca-blockers	Capillary blood	DBS	n/s	Flow-through desorption/SPE	Workflow automation	SPE–MS/MS	Validated, all drugs within limits	Not comparing plasma, focus on automation	Fully automated	[22]
Imipramine, Antivirals, Ca-blockers	Capillary blood	Volumetric DBS	10 µL	Direct online desorption	TDM/ automation	LC-MS	Linear, accurate, low RSD, good selectivity	Good correlation with plasma LC-MS/MS	Also: non-AD	[35]
Citalopram, Duloxetine, Mirtazapine, Paroxetine, Sertraline, Antipsychotics, Hypnotics	Post-mortem whole blood	DBS	50 µL	MeOH/ACN extraction, ultrasound	Forensic toxicology	LC-MS/MS	LOQ 0.002–0.01 µg/mL, rec 74–100 %, precise	Good correlation with QuEChERS	63 fatal cases	[25]
Citalopram, Mirtazapine, Antipsychotics	Capillary blood, serum	DBS	50 µL/spot	MeOH extraction, LLE	TDM	LC-MS	Linear 2.5–300 µg/L, accuracy/prec < 15 %	High DBS-serum correlation	Whole spot avoids Hct	[24]
Amitriptyline, Antipsychotics	Rat blood	DBS	20 µL	MeOH/H_2O extraction	Metabolite stability	LC-MS/MS	N-oxides revert, conversion card-dependent	Treated card = higher conversion, bias	See PDF for details	[32]
Nortriptyline, Desipramine, Amitriptyline, Doxepin, Imipramine, Trimipramine, Clomipramine	Plasma	Polymeric thin-film spot	10 µL	ACN extraction	TDM	LC-MS/MS	Linear, accurate/precise, stable 30d	Compared to DBS, similar/better sensitivity	Ready for POC use	[37]

(*continued on next page*)

Table 1 (*continued*)

Analyte(s)	Matrix	Microsampling technology	Sample volume	Sample treatment	Application	Analytical setup	Key findings	Bridging/ comparison	Notes	Ref.
Imipramine	Rat blood	Capillary microsampling	50 µL	P/P	Rat TK	LC-MS	50 µL: no toxicity/PK diff; 100 µL: RBC/HGB impact	Jugular/tail similar PK	Valid for TK	[34]
Trazodone	Rat plasma	Capillary microsampling	8 µL plasma	LLE, evaporation, reconstitution	Rat TK	LC-MS/MS	LLOQ 0.1 ng/mL, rec 78–92 %, linear, accurate	Not compared to others; CMS overcomes DBS Hct	Paediatric method	[20]
Amitriptyline, Nortriptyline, Citalopram, Mirtazapine, Paroxetine, Sertraline, Venlafaxine, Desvenlafaxine, Antipsychotics	Capillary/ venous blood, plasma	VAMS	10 µL	Dried, MeOH+IS, shake/sonicate/ centrifuge	TDM	LC-MS	Linear, most rec > 80 %, acc/prec < 15 % for most, validated	Capillary-plasma correlation, bias	/	[18]
Amitriptyline, Desipramine, Fluoxetine, Nortriptyline, Paroxetine, Sertraline, Trazodone, Venlafaxine, Antipsychotics, other CNS drugs	Post-mortem whole blood	DBS	85 µL	Extraction, SPE	Forensic; validation	LC-MS/MS	LOQs 5–10 ng/mL, validated/accurate/stable	DBS/liquid r^2= 0.93, DBS lower by ~15 %	60 post-mortem cases	[26]
Bupropion, Citalopram, Desipramine, Imipramine, Milnacipran, Sertraline, Vilazodone, Antipsychotics	Serum	Automated clinical kit	20 µL serum	P/P	Clinical automation; TDM	LC-MS/MS	LOQ 1 ng/mL, linear, automation=manual	Compared to commercial kit	Only 20 µL serum	[39]

plasma concentrations are well aligned via conversion factors or appropriate calibration [16,23,24]. Bland-Altman plots and regression are systematically used (Fig. 4).

Microsampling impact is clearest in patient-centric approaches (at-home sampling, minimal training, telemedicine and decentralised logistics) [10,15,17]. Patient-driven protocols have demonstrated high compliance in real-use studies, particularly with volumetric devices [18].

3.4. *Typical analytical workflow*

Typical steps include: (i) Sampling (capillary fingerstick; DBS/VAMS dried as per device instructions, or CMS aliquot in liquid form); (ii) Stabilisation & storage (ensure complete drying for dried formats; pouch/desiccant as applicable; appropriate containment/cold-chain for CMS where required); (iii) Pretreatment/extraction (e.g., whole-spot vs punch extraction for DBS; tip extraction for VAMS; clarification/ centrifugation or direct desorption where suitable); (iv) Instrumental analysis (commonly LC–MS or LC–MS/MS; HPLC–UV/FL where appropriate); (v) Validation (selectivity, accuracy,precision, linearity, matrix effect, stability); (vi) Bridging to plasma/serum when clinically necessary (regression and Bland-Altman); (vii) Reporting (matrix-specific or converted concentrations with stated conversion factors). See Figs. 2–4 and Table 1 for details and examples.

4. Experimental evidence: technologies and applications of microsampling for antidepressant drugs

The experimental literature reveals a rich tapestry of methodologies and applications across several studies encompassing clinical, preclinical and forensic samples. Volumetric approaches (VAMS, capillary- and microfluidic-generated DBS) stand out for superior operator-independence, limited haematocrit effect and exceptional stability, validated on several SSRIs, SNRIs and TCAs in both patient and decentralised scenarios [17,18,35]. DBS and its variants remain widespread, especially in longitudinal and large-scale population studies, with robust validation and successful control of matrix effects and punch variability [16,23,24,31]. Preclinical and paediatric workflows exploit CMS and similar small-volume devices to ethically enable PK/TK profiling in animal models [19,20,36]. Hybrid and automated workflows (e.g. PALME-DBS, online extraction) expand throughput, integration with mass spectrometry and potential for future large-scale deployment [21, 22,27,37–39]. Forensic and post-mortem applications further underline the analytical robustness and matrix flexibility offered by dried microsampling methods [25,26,40].

Validation now spans an ever-widening panel of ADs, with studies extending robust workflows from classic TCAs and SSRIs toward new-generation molecules [33,41,42]. The AD-focused corpus is assembled in Table 1 for quick navigation.

5. Discussion

Microsampling for ADs analysis has evolved from a technical innovation to a coherent methodological paradigm characterised by context-aware workflows and patient-aligned design, supported by device choices that can be adapted to specific analytical and clinical scenarios [16,23,24,27]. Persistent challenges remain: harmonising platforms, facilitating automation and tailoring protocols for unstable analytes and complex matrices [32,33,43]. Robust patient instructions and workflow integration will be essential for further decentralisation and telemedicine applications [10,18,44].

The expansion of microsampling into forensic and preclinical contexts is a testament to its versatility and the field's commitment to innovation, data integrity and ethical best practices [25,26,34]. In addition, the convergence of miniaturised sampling with modern mass spectrometry platforms and digital health infrastructure opens the path

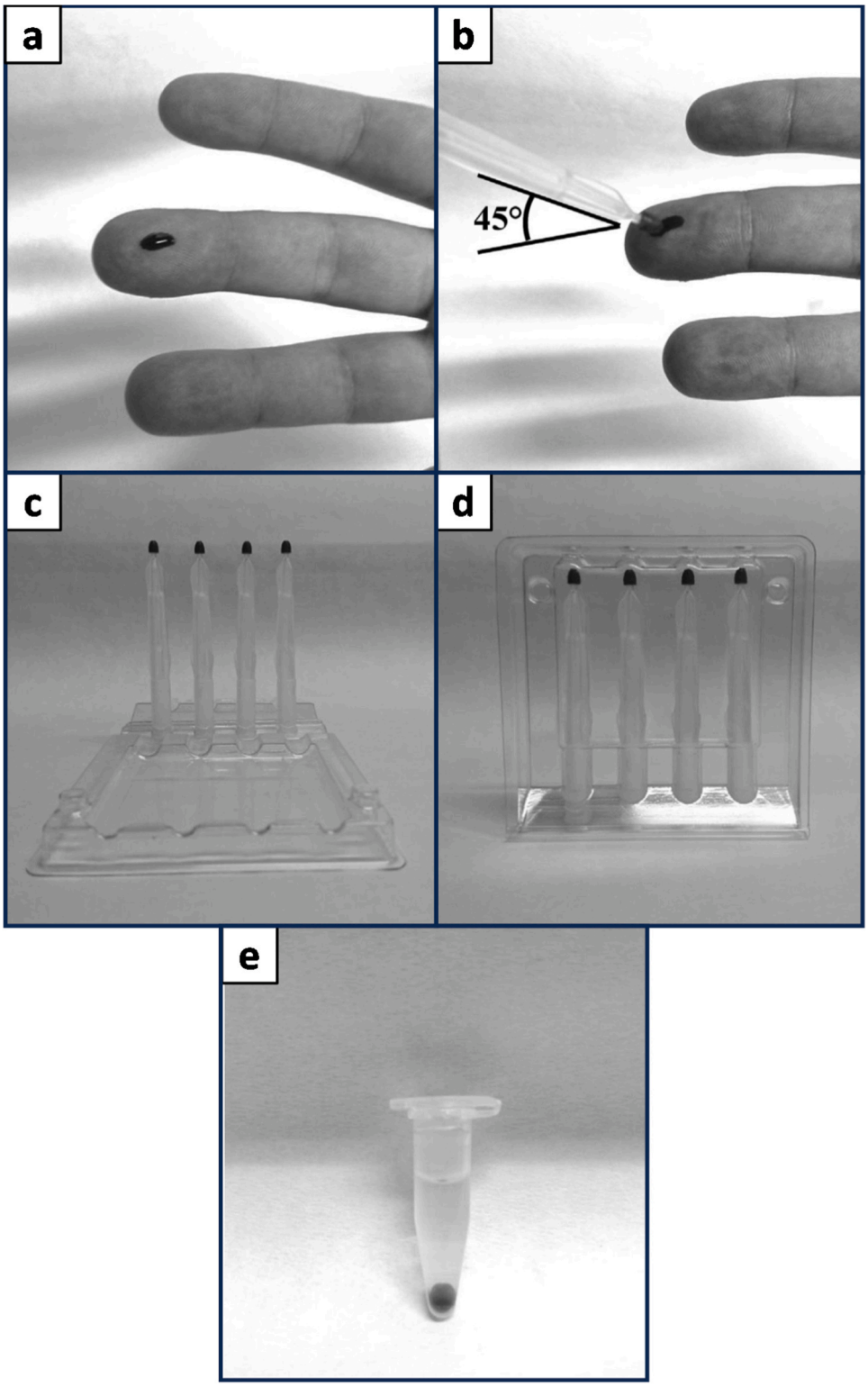

Fig. 3. Example of capillary blood VAMS sampling and pretreatment in a workflow applicable to antidepressant TDM: (a) a blood drop is obtained by finger pricking and (b) sampled by touching the blood surface with the VAMS device. Multiple VAMS blood samples (c) right after sampling and (d) enclosed in the dedicated clamshell container. (e) Sampled VAMS tip detached from the handle, in a microtube containing extraction solvent. Adapted from [9].

for scalable, high-throughput workflows. These may extend beyond classical TDM toward broader applications, such as population pharmacokinetics. Importantly, the use of volumetric devices and operator-independent formats increases analytical reproducibility and minimises sampling error (factors crucial for longitudinal and multicentric investigations). Nonetheless, some technical limitations must be acknowledged. Some analytes remain challenging due to degradation, poor extraction efficiency or inconsistent bridging with conventional matrices. The absence of harmonised protocols across devices and platforms hampers direct comparison between studies and delays clinical translation. Moreover, data on some AD classes (such as newer multimodal antidepressants) remain scarce in the microsampling

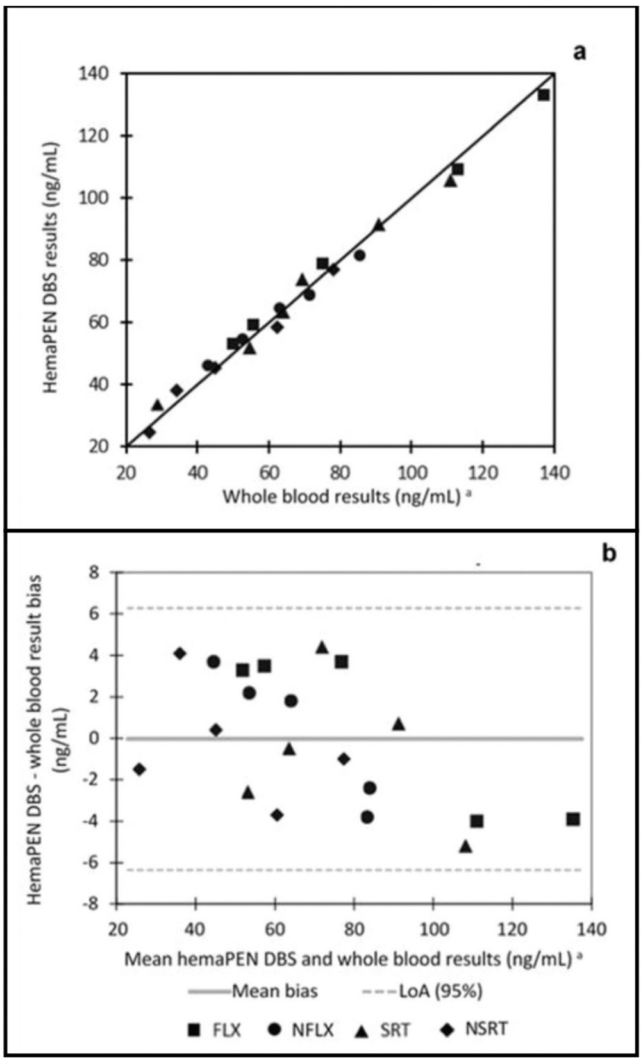

Fig. 4. Example of matrix comparison and bridging: (a) linearity correlation and (b) Bland-Altman plots for the comparison between capillary-generated DBS and fluid whole blood results. ([a] Plasma results converted to whole blood via blood-to-plasma factors). Adapted from [17].

literature, necessitating further targeted investigations. Ultimately, the successful integration of microsampling in AD pharmacotherapy will depend on rigorous analytical validation, sustained clinical engagement and effective communication between analysis laboratories and clinical teams.

6. Conclusions and perspectives

Microsampling technologies (a spectrum from volumetric and dried to hybrid platforms) are reshaping analytical, clinical and translational strategies in ADs research and care. Their future adoption requires ongoing device and method validation, harmonisation of reporting and coordinated integration into electronic health and laboratory automation platforms.

By advancing standardisation, user education and application in diverse populations, microsampling is poised to bridge historical gaps in AD TDM and to promote a more personalised, accessible, and robust approach to psychiatric pharmacology. Furthermore, the growing emphasis on remote healthcare delivery, decentralised trials and real-time monitoring makes microsampling an ideal complement to evolving models of psychiatric care. Its capacity to reduce patient burden, support for frequent sampling and delivery of high-quality data (even in non-clinical settings) aligns well with current priorities in precision medicine and value-based healthcare. Future research should prioritise longitudinal studies comparing microsampling with standard venous methods across varied demographic and clinical cohorts, including vulnerable populations. At the same time, investment in device innovation, automation-ready protocols and inter-platform comparability studies will be essential for widespread regulatory acceptance. Microsampling for ADs is no longer merely a technical alternative, it is emerging as a strategic asset in the modernisation of psychopharmacology.

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CRediT authorship contribution statement

Michele Protti: Writing – review & editing, Writing – original draft, Investigation, Data curation. **Roberto Mandrioli:** Writing – review & editing, Writing – original draft, Methodology, Data curation. **Laura Mercolini:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: R. Mandrioli, given his role as Advisory Editorial Board member in J. Pharmaceutical and Biomedical Analysis Open, had no involvement in the peer review of this article and had no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to another journal editor.

Data availability

No data was used for the research described in the article.

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