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The use of an innovative clinical decision support system focused on psychosocial vulnerabilities during pregnancy: the Born in Belgium Professionals Platform

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Abstract

Background Clinical Decision Support Systems (CDSS) assist care providers in enhancing their care processes. However, uptake—also called adoption, defined as the intent, initial decision, or action to try or employ an intervention at the provider or organisational level—is essential to their success. The Born in Belgium Professionals (BIB-Pro) platform—a CDSS—supports care providers in detecting and managing antenatal psychosocial indicators that may signal antenatal psychosocial vulnerability. It has been implemented across different antenatal care settings, including medical and social care settings.

Aim Due to limited research on CDSS uptake, especially in antenatal care settings, we aimed to assess the uptake of the BIB-Pro in real-life antenatal care settings. Additionally, we aimed to determine the prevalence of psychosocial indicators identified during pregnancy.

Methods This cross-sectional observational study was conducted between November 2020 and January 2024. Uptake was assessed among active users and settings through user uptake (i.e., the extent to which care providers used the platform and how this use evolved over time) and content uptake (i.e. progression through platform workflow pages). Data output included the prevalence of psychosocial indicators identified during screening and the registered care actions (i.e., registration of relevant care information, additional assessment, or referral to a care provider) undertaken within care pathways following identification of a psychosocial indicator. Data output analyses were restricted to the first registered file per woman.

Findings The platform was used in 39 antenatal care settings (15 hospitals, 14 primary care, 9 social care, and self-employed midwives grouped as one setting) and by 269 users. Uptake increased over time, with hospitals showing consistent use. Of all consented files, 95.1% ($n = 4303/4522$) underwent psychosocial screening. Among screened files, 80.4% (3461/4303) had at least one identified psychosocial indicator and were therefore eligible for action; of

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these, 85.2% ($n = 2950/3461$) had at least one documented action. Based on the first registered file per woman, 96.8% of screened women ($n = 4138/4273$) had at least one identified psychosocial indicator. The most prevalent indicators were low educational level (46.8%), medication use during pregnancy (37.4%), occupational status (31.5%), and psychological antecedents (28.7%). Depressive symptoms were identified in 19.5% of women, while 15.4% reported financial difficulties.

Conclusion The BIB-Pro platform showed promising uptake in real-life antenatal care settings and generated structured data on psychosocial indicators identified during pregnancy and related care actions. Its integration suggests potential to support antenatal psychosocial care and strengthen the identification and follow-up of psychosocial needs during pregnancy.

Clinical trial number Not applicable.

Keywords Pregnancy, Clinical decision support systems, Mental health, Implementation science, Psychosocial indicators, Psychosocial vulnerability, Adoption

Introduction

Statement of Significance		
Problem or Issue	What is Already Known	What this Paper Adds
Despite the recognised benefits of Clinical Decision Support Systems (CDSSs) in healthcare, less than 50% of such innovations are adopted in practice. Specifically, adoption (or uptake) of CDSSs targeting psychosocial vulnerabilities in pregnant women remains under-researched, with adoption rarely reported in existing CDSS studies. There is also a lack of data on antenatal psychosocial indicators and corresponding care actions in antenatal settings.	CDSSs can help healthcare providers improve screening and care processes. Reporting of adoption as an implementation outcome is scarce in CDSS research, especially in antenatal care. In antenatal care, most psychosocial screening relies on self-reported questionnaires without shared, integrated tools between care providers.	This study is the first to evaluate the real-world use of a shared CDSS for psychosocial care during pregnancy across both medical and social care settings. The BIB-Pro platform is integrated in hospital settings, with growing adoption over time. The study also offers one of the first national-level insights into the psychosocial indicators identified in pregnant women, alongside data on care interventions initiated through the platform.

Innovations, such as Clinical Decision Support Systems (CDSSs), that assist care providers by generating information and recommendations based on registered patient information [1], become more common in health care. These systems have demonstrated their impact on healthcare processes, for example, by increasing the delivery of preventive services such as screening and vaccination [2].

In Belgium, the Federal Health Care Knowledge Centre has identified the need for an evidence-based risk assessment, secure referral and collaboration tool for care providers during antenatal care [3]. Aligned with this, the Belgian government’s objective has been to enhance psychosocial antenatal care processes and access

by supporting care providers with a CDSS, the Born in Belgium Professionals (BIB-Pro) platform (www.born-inbelgiumpro.be). This CDSS supports care providers in identifying psychosocial indicators that may signal psychosocial vulnerability during pregnancy and guiding appropriate care. The platform is currently being implemented across medical and social antenatal care settings in Belgium.

Despite the potential of innovations such as CDSSs, their successful integration into routine practice remains challenging. According to research, less than 50% of clinical innovations are used in practice [4]. Kouri et al.’s systematic review and meta-regression analysis emphasise that the success of a CDSS, i.e. its impact on care processes and/or clinical or economic outcomes, depends on its adoption [5]. Within implementation science, adoption (also referred to as uptake) encompasses the intention, decision, or action to initiate, use or do an intervention [6]. Understanding adoption can support future interventions, implementations, care providers’ services, client outcomes, and policymakers’ decision-making regarding resource allocation.

However, adoption remains underreported in implementation research. According to a scoping review, only 24% of research on implementation outcomes examined adoption over the last decade [6]. The majority of publications that focus on implementation outcomes (i.e., the effects of deliberate and purposeful actions to implement new treatments, practices, and services [7]) tend to report more on perceptual implementation outcomes (i.e., acceptability, appropriateness, and feasibility) rather than behavioural implementation outcomes (i.e., adoption, fidelity, and reach/penetration) [6]. Nonetheless, the lack of reporting on behavioural implementation outcomes is also observed in CDSS studies, where only one in ten studies report on adoption (or uptake) [5]. Furthermore, evidence on CDSS implementation within perinatal care remains limited [8]. In particular, studies

examining the uptake of CDSSs in antenatal care settings are scarce [9].

To address this gap, the present study aims to analyse the uptake of the BIB-Pro platform implemented in real-life antenatal care settings. In addition, given that the platform identifies psychosocial indicators that may signal psychosocial vulnerability during pregnancy, this study also explores the data generated through its use.

Specifically, we examine: (1) ‘How is the uptake of the BIB-Pro platform in real-life antenatal care settings?’ And (2) ‘What data output was generated through the use of the platform, specifically the prevalence of psychosocial indicators identified during pregnancy and the actions registered?’

Methods

The Born in Belgium Professionals Platform

The BIB-Pro platform is a knowledge-based shared CDSS designed for care providers. “Shared” refers to the fact that multiple authorised care providers within and across settings can access and document information within the same patient file. The platform supports the identification of psychosocial indicators that may signal psychosocial vulnerability during pregnancy and guides care providers in addressing these needs. Detection is performed using a self-developed screening questionnaire that includes validated screening instruments [10]. Importantly, this questionnaire identifies indicators requiring attention rather than establishing diagnoses or labelling individuals as vulnerable. When an indicator is identified, guidance is provided through care pathways offering information, recommendations, and referral suggestions. The development of the platform, which integrates with Electronic Health Record (EHR) software and has interoperability capabilities, is described in Sect. “The development of the Born in Belgium Professionals Platform”.

The platform, available in French, Dutch, English, and German, is intended solely for care providers (i.e., the users) to use during consultations. It is accessible to those with a therapeutic relationship (i.e., the professional relationship of trust and collaboration between a healthcare provider—such as a therapist or physician— and a client/patient). Access to platform functionalities is role-based, meaning that authorised users may have either full or restricted access to specific data entry fields depending on their professional role. Supplementary File 1 gives an overview of the platform’s content. The first page (i.e. the registration page) requires patient identification, either by a Social Security Identification Number (SSIN) or an alternative unique identifier (AUI). Secondly, the ‘consent page’ is where users register the woman’s consent to create a BIB-Pro file and use the anonymised data for statistical purposes. The woman is provided with a brochure and an explanatory video about the BIB-Pro platform.

Thirdly, the patient information page (also called ‘patient page’) captures name, address, postal code, and expected delivery date. Fourthly, the ‘team page’ offers an overview of care providers involved, along with their contact details. Additionally, this page allows for the designation of the main care provider, who is responsible for overseeing care during pregnancy. The platform’s fifth page (i.e. ‘screening page’) includes a psychosocial questionnaire that measures indicators of antenatal psychosocial vulnerability [10]. Once an indicator is identified from the questionnaire, a corresponding care pathway appears on the sixth page (i.e. ‘action page’) of the platform. Data entry within the platform is primarily structured through selectable response options, enabling standardised documentation and tracking of care actions. Optional open-text fields are available to capture additional information.

Through colour coding in the action page, the platform communicates to users having access to the same file whether actions—such as completing additional questions within a care pathway to receive tailored recommendations, registering relevant care information (e.g., adding existing care provider to a care pathway), or making referrals (e.g., selecting a care provider for follow-up care)—have been initiated, completed or remain pending. For example, when symptoms of depression are identified, one possible action is referral to a psychologist by selecting an appropriate provider within or outside the setting (see Supplementary File 1, Sect. 8). The action is then registered as initiated.

The development of the Born in Belgium Professionals Platform

The development of the BIB-Pro platform consisted of four phases over the course of one year. **First**, an antenatal psychosocial vulnerability questionnaire was developed, which is described in our previous paper (Amuli et al., 2021) [10]. The questionnaire measures 15 indicators of antenatal psychosocial vulnerabilities, including communication, place of birth, residence status, education, occupational status, partner’s occupational status, financial situation, housing situation, social support, psychological antecedent, depressive symptoms, anxiety symptoms, medication use, substance use, and interpersonal violence. This questionnaire is available in 12 languages and can be completed during the first or following consultations.

Second, a co-creation process was established to develop care pathways linked to the psychosocial indicators. Care providers were invited, health and welfare organisations active in the field of (antenatal) care, along with experts in domains of psychosocial vulnerabilities, to determine the minimal care support needed for each pathway. Over 160 organisations participated in a 3-day workshop discussing the content of these care pathways.

The 3-blackboard method [11] was used for constructing care pathways.

In total, nine care pathways were developed, corresponding to 11 of the 15 psychosocial indicators included in the screening: communication, residence status, financial situation, housing situation, social support, mental health (which comprises psychological antecedent, depressive, and anxiety symptoms), medication use, substance use, and interpersonal violence. The other four indicators (i.e., country of birth, occupational status, partner's occupational status) were considered informative and not linked to any care action. The activation of a care pathway is described in Supplementary File 2.

A care pathway may include informational content sourced from literature or federal recommendations, along with actionable suggestions such as conducting a thorough assessment of the situation or making targeted referrals.

In the **third** phase, in line with national and European legislation, we invested in juridical and technical developments. For the juridical aspect, a Data Protection Impact Assessment (DPIA) and contracts regulating platform access, use, data sharing, data storage, and data processing were developed. In addition, informed consents and information leaflets for women were developed. A Data Protection Officer (DPO) was hired for the General Data Protection Regulation (GDPR). Furthermore, the IT Company LeapStation performed the technical development and digitalisation of the questionnaire and the care pathways. The platform is intended for use during patient encounters and contains different technical features: 1) it integrates a cloud-native Software-as-a-Service (SaaS) solution combining microservices, such as a multilingual questionnaire; 2) a wizard-based interface guiding users through a stepwise workflow, with mandatory field validation preventing progression until required fields are completed 3) structured data entry using predefined response options, with no free-text input except for optional notes 4) data exchange through Fast Healthcare Interoperability Resources (FHIR) standard to connect patients, healthcare providers, and care pathways data. This FHIR feature also offers “plugged in” systems for open data sources such as the national database of healthcare providers, social maps containing health and welfare organisations, and others; 5) an Application Programming Interface (API) to enable interoperability (i.e. data exchange) between the BIB-Pro platform and EHR software packages. Moreover, a Single Sign-On API was created to call BIB-Pro from a patient file; 6) a user access management system to respect the therapeutic care relationship (i.e., the professional relationship of trust and collaboration between a healthcare provider and a client/patient) and professional secrecy-dependent access; and

lastly, 7) access through a web-link or an EHR software-integrated access.

In the **last phase**, the platform was tested in a hospital setting and adjusted for technical bugs and layout. As such, the end product of the platform is a collaborative (or shared) platform that complies with the framework on integrating social determinants into primary care [12] and with recommendations for successfully implementing guidelines-based CDSS [13].

Design

This is a cross-sectional observational study analysing all data registered in the BIB-Pro platform between November 23rd, 2020, and January 18th, 2024. The Ethics Committee of UZ Brussels approved this study (B.U.N. 143201941861) on December 18, 2019. Institutions and partners agreeing to the platform's implementation provided an informed consent for data collection and analysis as part of the evaluation process by signing the implementation contract.

The study focused on implementation research to investigate the uptake of a CDSS among care providers in real-world antenatal care settings. In this study, a “setting” refers to an organisational care context (e.g., hospital, primary care practice, or social care service).

Implementation research, as defined by Eccles and Mitman (2006), focuses on understanding the processes and factors that influence the uptake of evidence-based interventions into routine practice [14]. Within implementation research, uptake (often used interchangeably with or defined as adoption) is defined as the intent, initial decision, or action to try or employ an innovation or evidence-based practice at the provider or organisation level. Focusing on uptake at the providers (here, i.e. users) level provides insights into individual behaviours and interactions with the platform [7].

Inclusion criteria

Inclusion criteria regarding uptake

Using platform-generated data, uptake was measured by quantifying user activity in the platform. We included settings where the platform was implemented (i.e. Brussels Capital region and Flanders), and where activity or engagement (i.e. registering at least one entry) in the platform was registered. We focused our analysis on uptake among active users (i.e. users who registered at least one entry in the consent page, team page, patient page, screening page or action page) rather than registered users (i.e. care providers with an account). This is because of the automatic registration of a care provider, regardless of their intent or relevance to use the platform, during the IT integration of the platform in EHR softwares. Automatic registration does not necessarily indicate intent, engagement or action; including these users

could misrepresent platform uptake. By analysing active users, a more accurate assessment of the actual uptake of the platform was ensured.

This study not only aims to assess whether the platform is used (i.e., the number of active users and settings), but also how it is used in practice once adopted (e.g., continuity of use, content uptake, and engagement with the platform workflow). Understanding this latter aspect is essential, as not every platform that is used at least once is subsequently used consistently, as intended, or in a way that leads to care-related actions. Therefore, we focused on active users, as population-level uptake primarily provides insight into the extent to which an innovation is adopted across settings, but does not capture how it is used in practice, whether it is integrated into care processes.

Inclusion criteria regarding data output

BIB-Pro files of women who gave their informed consent for statistical analysis were included. The platform is designed to be used during routine antenatal care and may be applied at any stage of pregnancy, depending on the organisational workflow of the care setting. Therefore, no predefined screening time point was imposed in this study.

Only the first registered file in the platform for each woman was included, and files from subsequent pregnancies were excluded. Analysing the first registered files provides us with an initial overview of the prevalence of psychosocial indicators identified among pregnant women and how care providers address these issues.

Analysis

Contextual characteristics of settings

To support the interpretation of uptake patterns, contextual characteristics of participating settings were described. These characteristics were obtained from the BIB-Pro project database and implementation records. They included setting type (hospital, primary care, social care, and self-employed), BIB-Pro integration within EHRs, and the likelihood of a setting being in contact with pregnant women. Characteristics were summarised descriptively by setting type. For analytical purposes, self-employed care providers were grouped and analysed as a single setting.

Uptake

In this study, uptake refers to the extent to which the BIB-Pro platform was taken up in routine antenatal care practice. Uptake was assessed through user and content uptake of the platform. User uptake describes how many care providers used the platform and how this use evolved over time. It does not reflect the proportion of all eligible users, as denominator data on all eligible

providers were not available through platform-based data collection.

Content uptake describes how users progressed through the different pages of the platform workflow.

Analysis of user uptake User uptake describes the extent to which care providers used the platform and how this use evolved over time. User uptake was assessed across three domains: (1) the number and distribution of active users, reflecting the extent of platform use across settings; (2) changes in user activity over time, reflecting the evolution and continuity of platform use; and (3) collaboration within the platform, providing additional insight into multi-user involvement in care processes. Measurements of user uptake of the BIB-Pro platform are described below and in Table 1.

The number and distribution of active users The total number of active users was measured by counting all users who showed activity on the platform (i.e. registering at least one data entry). The total number of active settings was defined as the number of settings with at least one active user. The distribution of active users across settings was determined by counting the number of active users within each identified setting type (i.e., hospital, primary care, social care, and self-employed settings).

Evolution of active users and settings over time The number of active users and the number of active settings were calculated for each timeframe. Trends over time were described descriptively and analysed by setting type. A timeframe was defined as a consecutive three-month period within the overall data collection period, corresponding to a year quarter.

Changes in user activity across settings over time User activity across settings over time was characterised by calculating, for each timeframe, the mean number of active users per active setting. The mean number of active users per active setting was calculated by dividing the total number of active users by the number of settings with at least one active user within each timeframe.

Changes in user activity within settings over time Additionally, the number of settings that gained, maintained or decreased in the number of active users since their first activity in the platform was examined. This was done by comparing the number of active users during the last activity timeframe of a setting with the first activity timeframe. Changes in activity within settings were further examined by measuring discontinued activity, defined as the number of timeframes in which no active users were registered. For each setting, the number of such timeframes was counted, after which settings were

Table 1 Measurement of user uptake of the BIB-Pro platform

Domain	Measurement of user uptake based on	Calculation / Definition
Number and distribution of active users	Total number of active users	Count of all users who showed activity on the platform
	Total number of active settings	Number of settings with ≥ 1 active user
	Active users by setting type	Count of active users within each type (hospital, primary care, social care, self-employed)
Evolution of active users and settings over time	Number of active users or settings per timeframe	Count of users or settings with ≥ 1 recorded activity within each timeframe (year quarter)
User activity across settings over time	Mean number of active users per active setting	Total active users $\div$ number of active settings within each timeframe
	Definition of timeframe	Consecutive three-month period (year quarter)
User activity within settings over time	Settings with increased, stable or decreased number of active users	Comparison of the number of active users in the first vs. last observed timeframe per setting
	Discontinued activity	Number of timeframes in which no active users were registered per setting
	Frequency of discontinued activity	Settings grouped by number of discontinued timeframes and reported as N (%)
Collaboration within the platform	Multi-user involvement	Proportion of files involving ≥ 2 users
	Multi-settings involvement	Proportion of files involving ≥ 2 settings

Table 2 Definitions and calculation of engagement metrics across the BIB-Pro platform workflow

Page	Measurement on each page of the BIB-Pro platform based on	Percentage of engagement on next page calculated as
Registration page	Number of created files	—
Consent page	Number of files with consent	Consented files $\div$ created files
	Number of files consented for statistical analysis	Statistical consent files $\div$ consented files
Patient page	Number of files in the patient page with a postal code	Files with postal code $\div$ files with statistical consent
Team page	Number of files in the team page with a 'main care provider'	Files with main care provider $\div$ files with postal code
Screening page	Number of files in the screening page with ≥ 1 question completed	Files with screening $\div$ files with main care provider
Action page	Number of files eligible for action (≥ 1 positive screening)	Eligible files $\div$ files with screening
	Number of files with ≥ 1 action performed in the care pathway	Files with action $\div$ eligible files

grouped according to the frequency of discontinued activity and reported as N (%).

Collaboration within the platform Lastly, collaboration was assessed using the proportion of files involving two or more users and two or more settings.

Analysis of content uptake Content uptake describes the extent to which platform functionalities were taken up in practice. It was assessed by analysing (1) the progression of patient files through the platform workflow, (2) the uptake of psychosocial screening and care actions, and (3) the timeliness of screening.

Engagement with the platform workflow across pages Engagement with the platform workflow was examined through a stepwise analysis of BIB-Pro files across the different platform pages: registration, consent, patient information, care team, screening, and action.

For each page, the number of BIB-Pro files with at least one completed field was calculated. Engagement across the workflow was then assessed by determining the proportion of files that progressed from one page to the next.

Progression to the next workflow step was calculated using the number of files recorded on the preceding page as the denominator. For example, the proportion of files with a registered main care provider was calculated by dividing the number of files with a main care provider by the number of files with a postal code registered on the patient page, which represents the preceding step in the workflow.

A file was considered present on a page when at least one relevant data field had been completed. The operational definitions and conditions for data entry on each page are described in Table 2.

Screening uptake and action uptake To further characterise the use of the platform's core functionalities (i.e., screening and action), screening uptake was calculated as the proportion of files in which psychosocial screening was completed among files that had consented for statistical analysis.

Action uptake was defined as the proportion of files in which at least one action was recorded among files that were eligible for action following screening. Files were

considered eligible for action when the screening identified at least one psychosocial indicator.

Timeliness of screening To assess the timing of platform use within the care process, the time interval between file creation and completion of the first psychosocial screening was analysed. The proportion of files in which screening occurred within one day after file creation was calculated.

Data output

The data output includes women's background characteristics, the presence of care providers during pregnancy, psychosocial indicators, and care pathways where actions were taken. For each woman, only the first registered file in the platform was retained for analysis.

Women's background and general information Regarding background characteristics, we reported the woman's residence region by postal code and reported whether she had a Social Security Identification Number (SSIN), a BIS number (i.e. a number for non-Belgian citizens without a valid Belgian eID and not domiciled in Belgium), or an alternative unique number (AUI) if neither was available. Gestational age at registration and the first screening were reported. The presence of health insurance at registration was also registered.

Care providers involved in antenatal care The presence of key care providers involved during pregnancy, such as obstetricians, general practitioners, and midwives, was assessed.

Psychosocial screening and indicators Regarding psychosocial screening, we examined the number of women with at least one psychosocial screening. Among women with at least one screening, screening completion was evaluated depending on user access rights. Screenings were considered complete when all questionnaire items were filled in for users with full platform access, and when

all items available within the permitted access level were completed for users with restricted access rights.

Next, among women with at least one screening, the presence of psychosocial indicators was assessed. The frequency of selected questionnaire response items was first examined. Based on predefined criteria, these responses were used to determine whether a psychosocial indicator screened positive. A positive screening was recorded when the predefined criteria were met. We also examined the number of women with at least one psychosocial indicator among the 15 indicators included in the screening and the number of women with at least one indicator among the 11 indicators linked to a care pathway.

These predefined criteria are detailed in our previous publication [10] and in Supplementary File 2. Note that the cut-offs of the validated questionnaire included in our psychosocial questionnaire were used: Oslo-3 [15] for social support, Whooley [16] for depressive symptoms, and GAD-2 [17] for measuring anxiety symptoms.

Actions undertaken in the care pathways To report on the actions performed in the care pathways, the frequency of files with at least one registered action was analysed. This included structured data entries from selectable response options; entries from optional open-text fields were excluded. Within each care pathway, percentages of actions and referrals were calculated among cases with a psychosocial indicator corresponding to that pathway.

Results

Contextual characteristics of settings

Thirty-nine medical and social care settings used the platform, registering 5039 files for 4995 women. The settings were mostly located in the centre (Brussels Capital Region) and the northern region of Belgium (Flanders). The participating settings comprised 15 hospital settings, 14 primary care settings, of which the majority are midwifery practices, 9 social care settings, which in this sample mainly focused on postpartum and child support, and 13 self-employed midwives considered as one setting (Table 3).

Across setting types, BIB-Pro integration within EHRs was present in the majority of hospital, primary care, and self-employed settings, whereas social care settings reported none or only minority integration. Similarly, most hospitals, primary care, and self-employed settings were classified as more likely to be in contact with pregnant women, while social care settings were considered less likely (Table 3).

Uptake

User uptake of the BIB-Pro platform in real-life settings

The number and distribution of active users Across the study period, a total of 269 users were active on the plat-

Table 3 Contextual characteristics of participating settings

Characteristic	All settings	Hospital	Primary care	Social care	Self-employed
Number of settings	39	15	14	9	1
Geographic concentration	Brussels & Flanders	—	—	—	—
BIB-Pro integration in EHR	Majority	Majority	Majority	None/minority	Majority
Likelihood of contact with pregnant women	More likely	More likely	More likely	Less likely	More likely

*Self-employed care providers are grouped as one setting

form at least once across 39 settings (Table 4). Hospital settings had the largest number of active users ($n = 175$), followed by primary care ($n = 63$), social care ($n = 18$), and self-employed midwives ($n = 13$). In total, 5039 files were created, predominantly within hospital settings ($n = 4790$).

Evolution of active users and settings over time Over time, both the number of active users and the number of active settings increased, particularly from Q4 onwards. Hospital settings consistently accounted for the largest number of active users. Medical settings also increased over time, although to a lesser extent. Social-oriented settings contributed fewer active users compared to hospital and medical settings, and their activity levels remained relatively stable over time. The number of active settings increased over time, indicating progressive organisational uptake of the platform (Figs. 1 and 2).

Changes in user activity across settings over time As shown in Fig. 3, the mean number of active users per active setting fluctuated over time but showed an overall upward pattern across the study period. After an initial

Table 4 User uptake by setting type

Indicator	All settings	Hospital	Primary care	Social care	Self-employed*
Number of active users	269	175	63	18	13
Number of files created	5039	4790	159	24	66

*Self-employed care providers are grouped as one setting

decrease from 4.0 in Q0 to 3.1 in Q1, the mean increased to 4.7 in Q2 and remained relatively stable between 4.0 and 4.7 in subsequent timeframes, before reaching its highest level in Q8 (5.8).

Changes in user activity within settings More than half of the settings (51.3%) gained and maintained their number of active users, particularly hospital settings (73.3%) (Table 5). Social care settings most often showed a decrease (88.9%).

Discontinued activity was absent in 53.8% of settings ($n = 21$). One discontinued timeframe was observed in 38.5% ($n = 15$), and recurrent discontinued activity (2–3

Number of active users over time

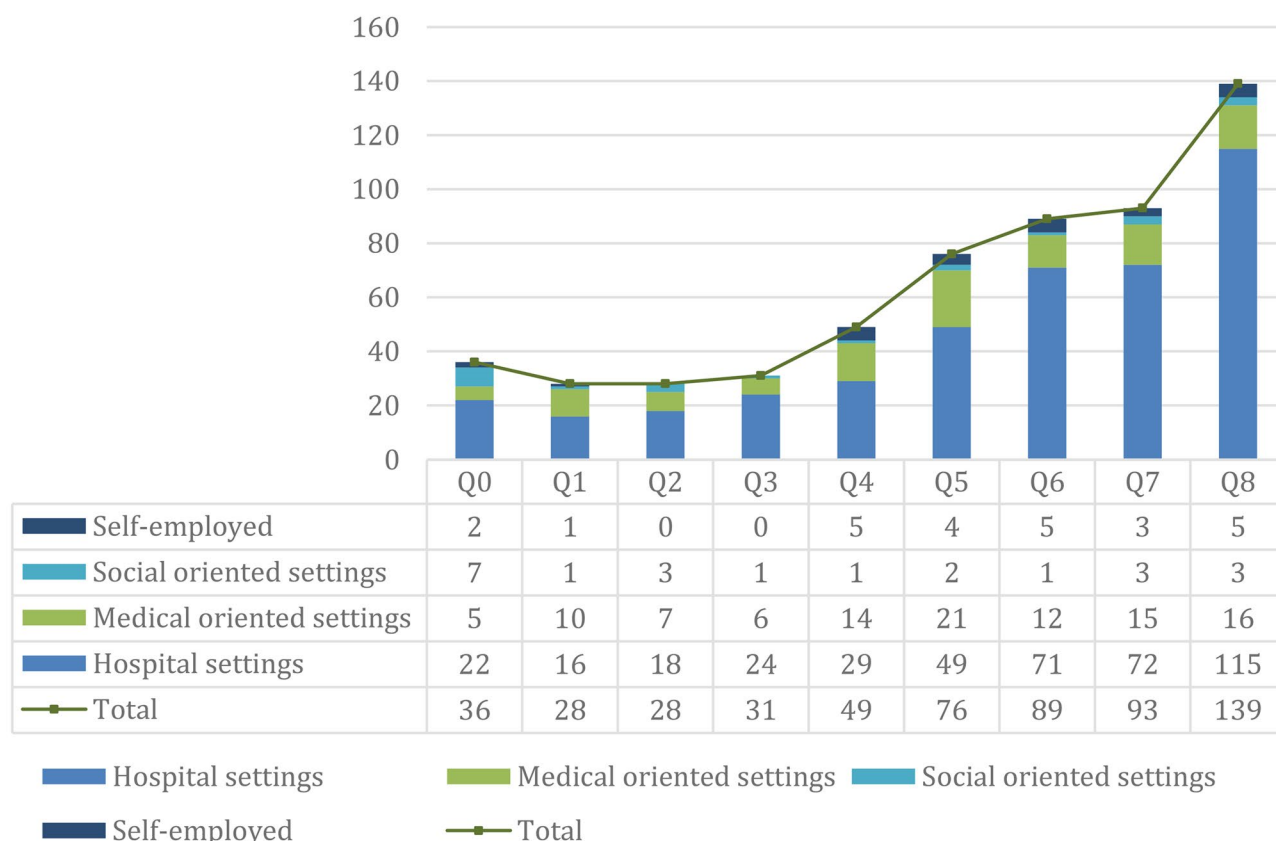


Fig. 1 Number of active users over time

Number of active settings over time

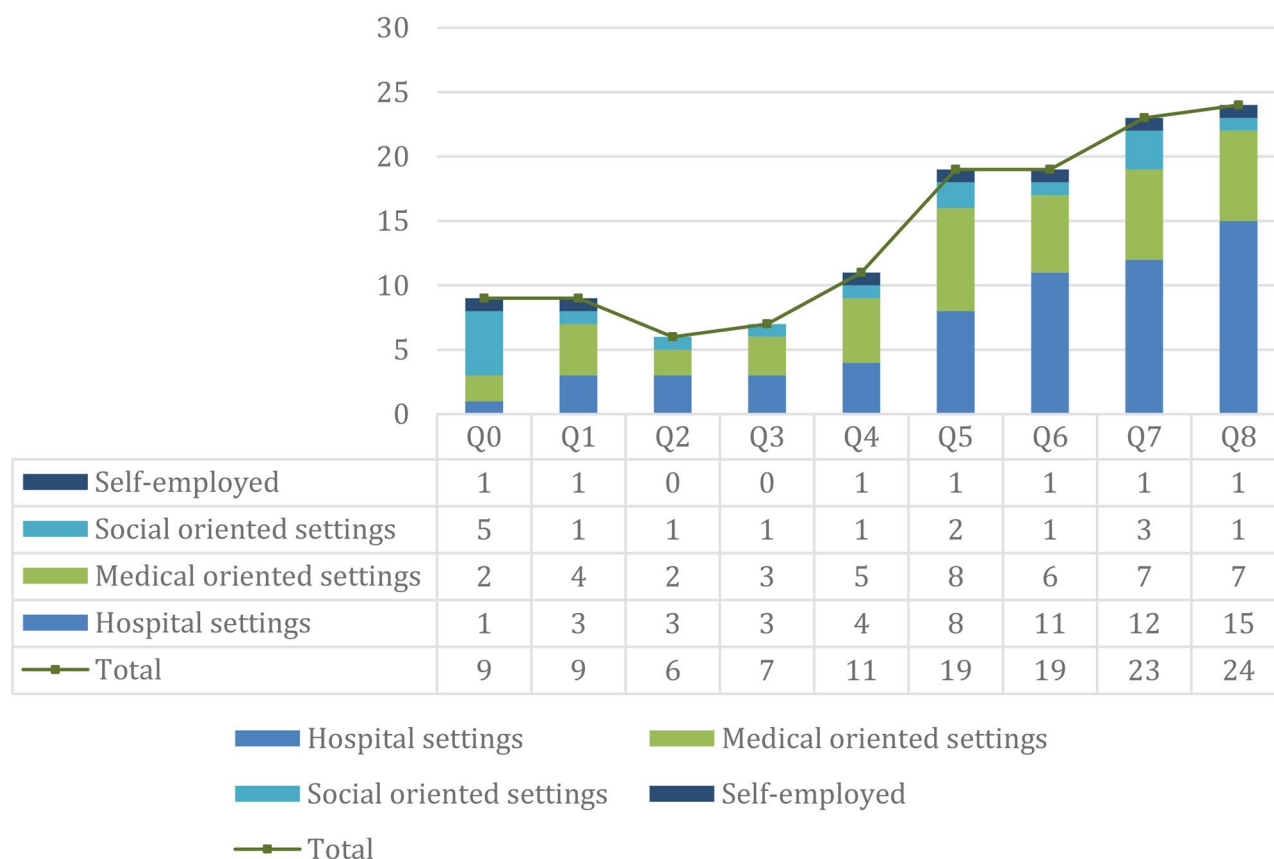


Fig. 2 Number of active settings over time

timeframes) occurred in 7.7% ($n=3$). Hospitals were the only settings without discontinued use (Table 5).

Collaboration within the platform Two or more users were involved in 11% of the files, and collaboration between at least two settings occurred in 1% of the cases.

Content uptake of the BIB-Pro platform in a real-life context

Care providers created 5039 files, of which 1.6% were blocked due to women's refusal to consent to file registration in the platform. Subsequently, approval for statistical analysis was given for 91.2% of the 4958 consented files.

Engagement with the platform workflow across pages

Engagement with the platform workflow remained high across the different platform pages. As shown in Table 6, at least 80% of files progressed to the subsequent workflow step. Nearly all files with statistical consent contained patient information on the patient page, with 99.9% ($n=4521/4522$) having a registered postal code. Among these files, 95.7% ($n=4327/4521$) had a registered main care provider on the team page. Almost all files that

reached the team page proceeded to the screening page (99.4%, $n=4303/4327$).

Table 6 presents the number of files recorded on each platform page and the proportion of files progressing to the next workflow step.

Screening uptake and action uptake Among the files consented for statistical analysis, 95.1% ($n=4303/4522$) of the files underwent screening. Among the files where screening was done, 80.4% ($n=3461/4303$) were eligible for at least one action based on the presence of psychosocial indicators. Among these eligible files, at least one action was recorded in 85.2% ($n=2950/3461$).

Timeliness of screening Timing between creation and first screening within one day occurred in 94.4% ($n=4267/4522$) of the files.

Data output

Among the BIB-Pro files with statistical consent, 4481 unique women were identified after restricting the

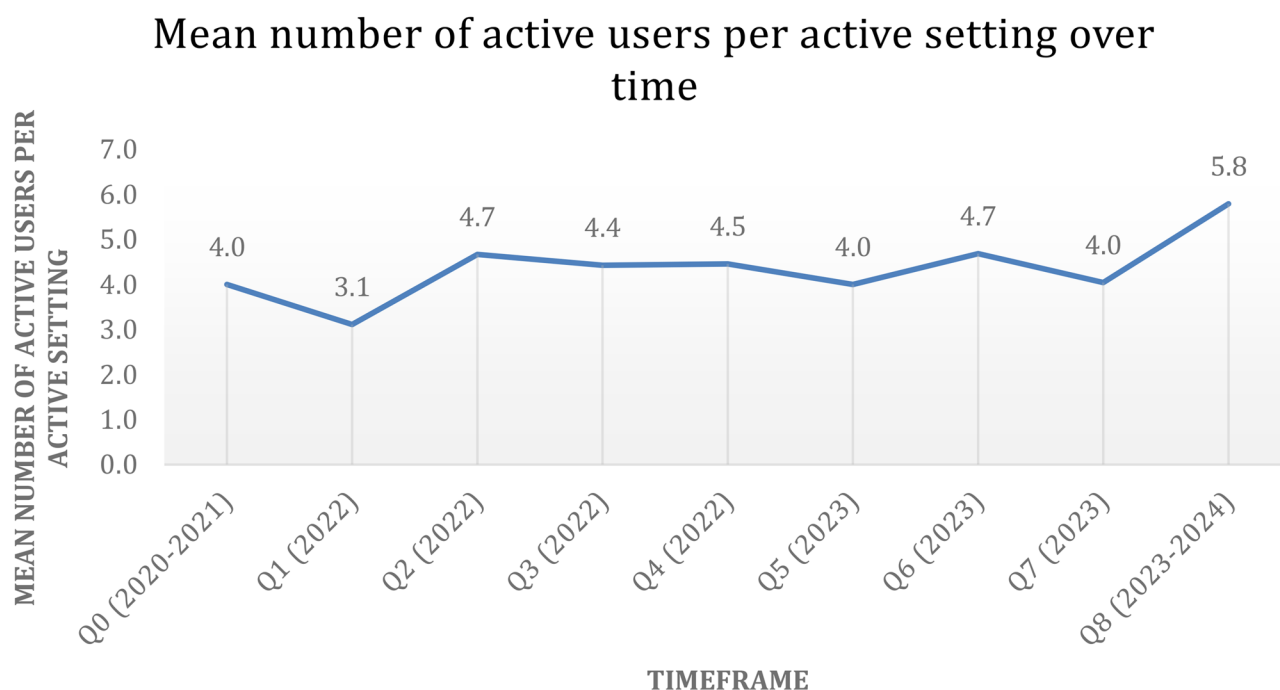


Fig. 3 Mean number of active users per active setting over time. 'Q' refers to a quarterly timeframe (i.e., a year quarter or a three-month timeframe). Note that Q0 covers the period from November 23, 2020, to the end of 2021. This adjustment was made due to difficulties in representing three-month intervals of that period. Q8 includes the last three months of 2023 up to January 18, 2024

Table 5 Changes in user activity within settings

Change in number of active users, n (%)					
Trend	All settings	Hospital	Primary care	Social care	Self-employed*
Increase	13 (33.3%)	8 (53.3%)	4 (28.6%)	—	1 (100%)
Maintain	7 (18.0%)	3 (20.0%)	3 (21.4%)	1 (11.1%)	—
Decrease	19 (48.7%)	4 (26.7%)	7 (50.0%)	8 (88.9%)	—
Discontinued activity, n (%)					
Frequency of discontinued activity	All settings	Hospital	Primary care	Social care	Self-employed*
0 times	21 (53.8%)	15 (100%)	6 (42.9%)	—	—
1 time	15 (38.5%)	—	7 (50.0%)	7 (77.8%)	1 (100%)
2–3 times	3 (7.7%)	—	1 (7.1%)	2 (22.2%)	—

*Self-employed care providers are grouped as one setting

dataset to the first registered file per woman. These women were included in the data output analyses.

Women's background and general information (n = 4481, women)

The majority of women resided in Flanders (63.6%, $n = 2851$), followed by the Brussels Capital Region (35.6%, $n = 1595$). Thirty-two women resided in Wallonia and three outside Belgium. Most women (99.0%) were at least once registered in the platform with a SSIN, while a minority (1.0%) had an identifier other than an SSIN.

The median gestational age when the BIB-Pro platform was accessed was 26 weeks (interquartile range (IQR) of 23 to 29 weeks). Most women (90.4%) registered in the

platform had health insurance, while in 9.6% either health insurance was lacking, or information was missing.

Care providers involved in antenatal care (n = 4481, women)

Among the 4481 women included in the data output analysis, Table 7 presents the care providers registered as involved in antenatal care. For almost all women, an obstetrician (97.5%), a general practitioner (95.3%) or a midwife (80.5%) was involved.

The main care provider during antenatal care was most commonly an obstetrician (59.4%, $n = 2550$), followed by a general practitioner (30.7%, $n = 1320$), and a midwife (4.9%, $n = 210$). In 5% ($n = 215$) of the cases, the main care provider was unspecified.

Table 6 Engagement with the BIB-Pro platform workflow across pages

Page	BIB-Pro files frequency	BIB-Pro Files continuing to next workflow step (%) ¹	
Registration page	Created files	5039	-
Consent page	Files with a consent	4958	98.4%
	Files consented for statistics	4522	91.2%
Patient page	Files with a postal code	4521	99.9%
Team page	Files with a main care provider	4327	95.7%
Screening page	Files with a screening	4303	99.4%
Action page	Files eligible for an action	3461	80.4%
	Files with actions	2950	85.2%

¹ Percentages represent the proportion of files continuing from the preceding workflow step

Table 7 Care providers involved in antenatal care ($n=4481$, women)

Care providers	Present	Absent	Total
Midwife N (%)	3435 (80.5%)	834 (19.5%)	4269 (100%)
Obstetrician N (%)	4161 (97.5%)	105 (2.5%)	4266 (100%)
General practitioner N (%)	4072 (95.3%)	199 (4.7%)	4271 (100%)

In 1% ($n=38/4348$) of the cases, additional (health) care providers were registered, including a psychologist, psychiatrist, tobacco specialist, social worker, or perinatal coordinator.

Psychosocial screening and indicators

Psychosocial screening In total, 4481 women with a first registered file in the platform were included in the analysis, of whom 4273 women (95.4%; 4273/4481) were screened for at least one psychosocial indicator. Among women with at least one registered screening ($n=4273$), 94.7% ($n=4046$) had a fully completed screening when the screening was performed by users with full platform access. Additionally, when screenings were performed by users with restricted access rights, 4201 of the 4273 screenings (98.3%) had all screening items that were accessible to these users completed.

Psychosocial indicators Among the women who underwent psychosocial screening, 96.8% ($n=4138/4273$) had at least one identified psychosocial indicator among the 15 indicators included in the screening. In addition, 69.8% of women ($n=2982/4273$) had at least one psychosocial indicator for which a care pathway was available in the platform. Not all psychosocial indicators were linked to a care pathway, which explains the difference between these proportions.

Table 8 reports on the presence of psychosocial indicators according to our predefined criteria (Supplementary File 2). The most prevalent indicator was low educational level (46.8%), followed by medication use during pregnancy (37.4%) and occupational status (31.5%). Psychological antecedents were reported by 28.7% of women, while 19.5% screened positive for depressive symptoms and 15.4% reported financial difficulties. Additionally, 12.9% of women reported having no partner or reported having a partner who was seeking employment, not professionally active, or a student.

Approximately 9–10% of women experienced low social support or housing problems. Substance use during pregnancy was reported by 8.6% of women overall, including tobacco use (6.2%), alcohol consumption (2.7%), cannabis use (0.6%), and other drug use (0.5%). Anxiety symptoms were present in 7.6% of women, and 5.5% experienced communication barriers.

The lowest prevalence rates were observed for the indicators residence status (1.4%) and interpersonal violence (2.0%). Within interpersonal violence, emotional violence was most frequently reported (1.8%), followed by physical (0.4%) and sexual violence (0.2%).

Actions undertaken in the care pathways

Actions were primarily taken for indicators such as mental health care (80.1%), medication use (79.7%), substance use (77%), communication (70%), violence (67.5%), financial situation (64.1%), housing situation (58.2%), social support (50.7%), and to a lesser extent residence status (48.3%) (Table 8). Referrals occurred mostly in the presence of the indicator housing (18.5%) and financial (17.9%). Furthermore, referrals were registered for mental health, substance use and social support, in about 10% of the cases.

Discussion

This paper presents the findings of the uptake and data output of an innovative shared CDSS platform designed for care providers, focusing on identifying and managing psychosocial indicators that may signal psychosocial vulnerability during pregnancy. Our first analysis revealed an integration of the platform in routine care amongst the included settings, reflected in both user activity (i.e., user uptake) and progression through the platform workflow (i.e., content uptake), and the psychosocial screening data and care actions generated through platform use (i.e., data output). Settings have integrated the platform into their practice and there is a rising interest and utilisation among users.

Concerning **user uptake**, our analysis revealed that uptake patterns differed across setting types, with hospital settings consistently accounting for the largest

Table 8 Overview of data output from the psychosocial questionnaire and care pathways

Psychosocial indicator: Questions (response rate: %, n)		Screening page ¹	Action Page ²	
Communication: How does she communicate? (response rate: 95.4%; n = 4273/4481)		Indicator identified % (n)	Action % (n)	Referral % (n)
Dutch, French and/or English	4039 (94.5%)	5.5%	70% (163)	5.1%
Through a partner or another person	202 (4.7%)	(234)		(12)
Through an intercultural mediator or social interpreter	20 (0.5%)			
Unable to communicate in Dutch, French and or English	12 (0.3%)			
Birth country: What is your country of birth? (response rate: 95.4%; n = 4273/4481)		Indicator identified % (n)	Action % (n)	Referral % (n)
NON-EU country	1665 (39.0%)	39.0%	n.a	n.a
EU country ³	2608 (61.0%)	(1665)		
Residence status: What is your residence status? (response rate: 95.4%; n = 4273/4481)		Indicator identified % (n)	Action % (n)	Referral % (n)
Legal residence in Belgium (recognised refugee included)	4151 (97.1%)	1.4%	48.3% (28)	5.2%
EU-tourist in Belgium with identity papers	50 (1.2%)	(58)		(3)
Tourist from outside the EU with health insurance	14 (0.3%)			
Asylum seeker (in procedure)	37 (0.9%)			
Tourist from outside the EU with NO health insurance	9 (0.2%)			
Undocumented	12 (0.3%)			
Educational level: What is your highest degree? (response rate: 94%; n = 4212/4481)		Indicator identified % (n)	Action % (n)	Referral % (n)
No degree	69 (1.6%)	45.9%	n.a	n.a
Primary education	93 (2.2%)	(1935)		
Lower secondary education	288 (6.8%)			
Higher, secondary education	1468 (34.9%)			
Higher, non-university education	1377 (32.7%)			
University education	900 (21.4%)			
Special needs education	17 (0.4%)			
Occupational status: What is your professional status? (response rate: 94.6%; n = 4237/4481)		Indicator identified % (n)	Action % (n)	Referral % (n)
I have a job	2903 (68.5%)	31.5%	n.a	n.a
I'm seeking a job	325 (7.7%)	(1334)		
I'm not active (a homemaker, disabled, without a job, inability to work,...)	882 (20.8%)			
I am a student	127 (3.0%)			
Partner's occupational status: Do you have a partner? If yes, what is the professional status of your partner? (response rate: 94.6%; n = 4237/4481)		Indicator identified % (n)	Action % (n)	Referral % (n)
I don't have a partner	174 (4.1%)	12.9%	n.a	n.a
My partner has a job	3689 (87.1%)	(548)		
My partner seeks a job	200 (4.7%)			
My partner is not active (a homemaker, disabled, without a job, inability to work,...)	139 (3.3%)			
My partner is a student	35 (0.8%)			
Financial situation: Are your financial resources sufficient? Can you make ends meet at the end of the month? (response rate: 93.8%; n = 4204/4481)		Indicator identified % (n)	Action % (n)	Referral % (n)
Yes	3556 (84.6%)	15.4%	64.0% (415)	17.9%
Yes, but I have to limit my expenses	430 (10.2%)	(648)		(116)
No, it is difficult to make ends meet	157 (3.7%)			
No, I have debts	61 (1.5%)			

Table 8 (continued)

Housing situation: Do you experience problems with your housing situation? (response rate: 93.8%;n = 4201/4481)		Indicator identified % (n)	Action % (n)	Referral % (n)
No, I have no problems with my housing	3812 (90.7%)	9.3%	58.1%	18.5%
Yes, because I don't have a permanent stay	47 (1.1%)	(389)	(226)	(72)
Yes, because my housing situation is not ideal (unsafe, unhealthy, too small...)	327 (7.8%)			
Yes, because I don't have a permanent stay and my housing situation now is not ideal (unsafe, unhealthy, too small,...)	15 (0.4%)			
Social support (response rate: 92.5%;n = 4143/4481)		Indicator identified % (n)	Action % (n)	Referral % (n)
Sub question 1: How many people are so close to you that you can count on them if you have great personal problems? (response rate: 92.8%;n = 4157/4481)		9.0%	50.5%	8.3%
None	154 (3.7%)	(372)	(188)	(31)
1 or 2	686 (16.5%)			
3 to 5	1347 (32.4%)			
6 or more	1970 (47.4%)			
Sub question 2: How much interest and concern do people show in what you do? (response rate: 92.5%;n = 4147/4481)				
A lot	2144 (51.7%)			
Some	1634 (39.4%)			
Uncertain	232 (5.6%)			
Little	68 (1.6%)			
None	69 (1.7%)			
Sub question 3: How easy is it to get practical help from neighbours if you should need it? (response rate: 92.6%;n = 4150/4481)				
Very easy	1986 (47.9%)			
Easy	1086 (26.2%)			
Possible	623 (15.0%)			
Difficult	296 (7.1%)			
Very difficult	159 (3.8%)			

Table 8 (continued)

Mental health (psychological antecedent, depressive symptoms, anxiety symptoms) (response rate: 91.7%;n = 4109/4481)		Indicator identified % (n)	≥ 1 indicator within domain identified % (n)	Action % (n)	Re-ferral % (n)
Psychological antecedent (response rate: 91.4%;n = 4109/4481)			39.7% (1632/4109)	80.1% (1307)	9.2% (150)
Have you been followed up for emotional and/or psychological problems in the past? (Such as anxiety, depression, bipolar disorder (or manic depression), postpartum psychosis, psychotic disorder, schizophrenia or other)		28.7% (1175)			
Yes	1175 (28.7%)				
No	2922 (71.3%)				
Depressive symptoms (response rate: 91.3%;n = 4093/4481)					
Sub question 1: During the past month, have you often been bothered by feeling down, depressed or hopeless?		19.5% (797)			
Yes	608 (14.9%)				
No	3479 (85.1%)				
Sub question 2: During the past month, have you often been bothered by little interest or pleasure in doing things?					
Yes	495 (12.1%)				
No	3584 (87.9%)				
Anxiety symptoms (response rate: 91.1%;n = 4083/4481)					
Sub question 1: Over the last two weeks, how often have you been bothered by feeling nervous, anxious or on edge?		7.6% (309)			
Not at all	2579 (63.3%)				
Several days	1216 (29.8%)				
More than half a day	125 (3.1%)				
Nearly every day	156 (3.8%)				
Sub question 2: Over the last two weeks, how often have you been bothered by not being able to stop or control worrying?					
Not at all	3148 (77.4%)				
Several days	703 (17.3%)				
More than half a day	94 (2.3%)				
Nearly every day	124 (3.0%)				
Medication use: Do you take medication during your pregnancy (naturopathy and homeopathy included)? (response rate: 90.6%;n = 4062/4481)			Indicator identified % (n)	Action % (n)	Re-ferral % (n)
Yes	1519 (37.4%)	37.4% (1519)		79.7% (1211)	1% (15)
No	2543 (62.6%)				
Substance use (alcohol, tobacco, cannabis, drugs) (response rate: 90.7%;n = 4064/4481)			Indicator identified % (n)	≥ 1 indicator within domain identified % (n)	Action % (n) Re-ferral % (n)

Table 8 (continued)

Medication use: Do you take medication during your pregnancy (naturopathy and homeopathy included)? (response rate: 90.6%;n = 4062/4481)		Indicator identi- fied % (n)		Action % (n)	Re- ferral % (n)
Have you ever consumed alcohol since you know you are pregnant? If yes, how often? (response rate: 90.7%;n = 4063/4481)		2.7% (109)	8.6% (348/4064)	77.0% (268)	9.8% (34)
Never	3954 (97.3%)				
Yes, 1 or 2 times this pregnancy	96 (2.4%)				
Yes, monthly	6 (0.1%)				
Yes, weekly	4 (0.1%)				
Yes, (almost) daily	3 (0.1%)				
Have you ever smoked since you know you are pregnant? If yes, how often? (response rate: 90.7%;n = 4064/4481)		6.2% (253)			
Never	3811 (93.8%)				
Yes, 1 or 2 times this pregnancy	38 (1.1%)				
Yes, monthly	2 (0.1%)				
Yes, weekly	15 (0.4%)				
Yes, (almost) daily	148 (4.7%)				
Have you ever used cannabis (marijuana, weed, hash ...) since you know you are pregnant? If yes, how often? (response rate: 90.6%;n = 4060/4481)		0.6% (25)			
Never	4035 (99.4%)				
Yes, 1 or 2 times this pregnancy	8 (0.2%)				
Yes, monthly	1 (0.0%)				
Yes, weekly	5 (0.1%)				
Yes, (almost) daily	11 (0.3%)				
Have you ever used drugs since you know you are pregnant? If yes, how often? (response rate: 90.2%;n = 4043/4481)		0.5% (22)			
Never	4021 (99.5%)				
Yes, 1 or 2 times this pregnancy	14 (0.3%)				
Yes, monthly	0 (0.0%)				
Yes, weekly	2 (0.1%)				
Yes, (almost) daily	6 (0.1%)				

Table 8 (continued)

Interpersonal violence (emotional, physical and sexual violence) (response rate: 89.8%;n = 4022/4481)		Indicator identified % (n)	≥ 1 indicator within domain identified % (n)	Action % (n)	Re- fer- ral % (n)
Emotional: Are you being emotionally abused by your partner or someone important to you? (response rate: 89.7%;n = 4018/4481)		1.8% (72)	2.0% (80/4022)	67.5% (54)	1.3% (1)
Never	3714 (92.4%)				
Yes, but in the past	232 (5.5%)				
Rarely	10 (0.2%)				
Sometimes	34 (0.8%)				
Fairly often	22 (0.5%)				
Frequently	6 (0.1%)				
Physical: Are you being physically hurt by your partner or someone important to you? (response rate: 89.3%;n = 4002/4481)		0.4% (17)			
Never	3817 (95.4%)				
Yes, but in the past	168 (4.2%)				
Rarely	5 (0.2%)				
Sometimes	9 (0.2%)				
Fairly often	2 (0.0%)				
Frequently	1 (0.0%)				
Sexual: Are you being forced to have sexual activities? (response rate: 88.7%;n = 3976/4481)		0.2% (6)			
Never	3847 (96.8%)				
No, but in the past	123 (3.1%)				
Rarely	4 (0.1%)				
Sometimes	2 (0.1%)				
Fairly often	0 (0.0%)				
Frequently	0 (0.0%)				

¹ Percentages for positive screening were calculated within each domain and represent the proportion of women meeting the predefined criteria for a psychosocial indicator

² Percentages for action and referral were calculated within each care pathway among women with a psychosocial indicator corresponding to that pathway

³ The list includes 15 countries from the European Union, including the United Kingdom as it was before Brexit

number of active users, while social care settings contributed fewer but stable user numbers.

The increase in active users over time occurred alongside the increase in active settings, suggesting that platform growth was mainly driven by the increasing number of participating settings. This interpretation is supported by the relatively stable mean number of active users per active setting over time, indicating that the observed growth in users reflects the participation of a greater number of settings rather than a substantial increase in users within individual settings. Moreover, the stronger growth observed in hospital settings may have influenced this pattern, as hospitals contributed a larger share of active users over time.

In line with these uptake patterns, the majority of settings maintained or increased their number of active users over time and discontinued activity was absent in more than half of the included settings. These findings suggest early signs of routine or sustained use. Discontinuity in platform activity occurred less frequently in medical settings. These differences observed between

setting types may stem from differences in their target group (i.e., their likelihood of being in contact with pregnant women), the role of the setting and its care providers within the platform, or the evolving collaborations among diverse settings facilitated by the platform. It is essential to acknowledge the key role of social care settings, particularly social workers, in the collaborative utilisation of the platform with various stakeholders. Social workers play an essential role in referrals; they have expertise in recognising and handling psychosocial needs [18, 19]. To our knowledge, this is the first time social settings are involved in a collaborative antenatal CDSS focused on psychosocial indicators during pregnancy. Typically engaged late in pregnancy or postpartum, their involvement in this antenatal psychosocial CDSS suggests a willingness to improve both antenatal psychosocial care and future postnatal CDSS rollouts.

The findings regarding user uptake suggest increasing organisational uptake of the platform, reflected by the growing number of participating settings, while uptake

within settings remained relatively stable and varied across organisations.

When it comes to content uptake, our analysis showed high engagement with the platform workflow across its different pages. Most files progressed through the successive workflow steps. Among the files that underwent screening, more than four out of five were eligible for at least one action based on psychosocial indicators, and at least one action was recorded in 85.2% of these eligible files. This proportion is three times higher compared to the responses to CDSS alerts observed in Kouri's systematic review [5].

Besides, the time between creating a file and starting a screening in the BIB-Pro platform was within a day in most files. This reaction time is similar to a study focusing on responding to medication advice using a CDSS [20], reinforcing that psychosocial care is as important as medical care [21].

The BIB-Pro platform is an innovative CDSS designed to support collaborative integrated psychosocial care in pregnancy. Numerous factors can play a role in the uptake of a CDSS. For instance, the number of available providers, user profile, integration and interoperability possibilities in EHRs may facilitate uptake, while limited knowledge, alert fatigue, lack of stakeholder involvement, and disruption of autonomy may hinder its use [5, 22, 23]. The uptake observed in our study might be attributed to the platform's potential to address numerous issues [3, 24, 25] encountered in the field, offering solutions such as bidirectional referrals among care providers, a cohesive and integrated care offer, and the facilitation of joint collaboration and communication among care providers [3, 24, 25]. In our previous publication, exploring users' perceptions of the platform, key motivators for BIB-Pro platform use included the psychosocial questionnaire, continuity of care, and supporting prevention [26]. By doing so, we were able to better understand whether interactions with the platform reflected positive user experiences or potential difficulties in its use, as behavioural metrics alone (e.g., clicks) cannot distinguish between these [27].

Designs such as encouraging the user to fill in mandatory sections, as is the case with the BIB-Pro platform, can influence user behaviour [28] and thus facilitate data entry. In our previous study, users indicated that the availability of resources facilitated platform use, while EHR integration and organisational support were identified as factors facilitating uptake [26]. The implementation of the BIB-Pro platform was also supported by several implementation strategies, which may have facilitated the uptake observed. Training and assistance were provided at each stage of the implementation process; these elements might explain the uptake in real-life settings [5, 29]. Additionally, collaborative groups were

established to ensure preparation, collaboration and continuity in the use of the platform [5, 29].

Regarding our second research question on **data output**, nearly all women approached consented to the creation of a BIB-Pro file, and most agreed to share their data for analysis. Other platforms like iCOPE [21], GyPsy [30], and MatChat [31] offer antenatal psychosocial screening and guidance similar to the BIB-Pro platform for care providers. However, their screenings rely on women's self-reported data. Interestingly, our platform's screening rate matches GyPsy's self-reported response rate of 94% [30], indicating high acceptability among women when screened by a care provider.

The high proportion of women with at least one psychosocial indicator reflects the broad scope of the screening questionnaire, which captures a wide range of psychosocial signals (of indicators) during antenatal care [10]. Importantly, not all indicators were intended to activate a care pathway. Some indicators aimed as informational indicators following expert consultation, meaning they provide contextual information for care providers but do not lead to a care pathway. Accordingly, only a subset of identified indicators corresponded to a care pathway in the platform, resulting in a smaller proportion of women having at least one psychosocial indicator for which a care pathway was available. This pattern reflects the design of the platform, which aims to detect psychosocial indicators broadly while assigning structured care pathways for indicators requiring further actions.

Most of the women legally resided in Belgium and had health insurance, as required by law. The number of uninsured pregnant women aligns with Vanneste et al.'s study in a Brussels public hospital [32]. Furthermore, women's educational level and occupational status are in accordance with regional and national data [33–36]. Reported financial difficulties in our study are slightly higher (16.1%) compared to a study performed in Flanders (14.7%) [37]. Housing problems (9.3%) is comparable to an extrapolation of poverty index data (7%) from Opgroeien, a Flemish governmental institution responsible for the support of families [36].

Concerning the care provider team in pregnancy, our results show that there is a greater number of women not having a midwife compared to not having an obstetrician or a general practitioner during registration. This finding reflects the Belgian antenatal obstetrician-led care system [25].

The data collected from the platform also provides an overview of pregnant women's mental health. One in ten women in our study seemed to have low social support, a result that is in line with findings about the general Belgian population (15%) [38], data from the Flemish Region (12.4%) [38] or data from the Netherlands (15%) [39]. Furthermore, the prevalence of single pregnant women

registered in the BIB-Pro platform is three times lower than the 2019 national data (14.9%) [40] but aligns with other research [39, 41, 42].

Psychological antecedents, depressive symptoms and anxiety symptoms in our study are also in line with other studies [43–48]. However, our numbers seem lower compared to a study done with the same Whooley and GAD-2 questionnaires but self-administered and for solely Dutch-speaking pregnant women [42].

Regarding undertaken actions and referrals made in the BIB-Pro platform, our results are in line with existing literature. Psychological support actions in our platform were offered to 4 out of 5 women while another study showed that psychological support, when detected, was offered to 1 in 3 pregnant women [49]. Moreover, our result on referrals is similar to a finding, reporting that 10–15% of pregnant women are being referred by midwives for psychological support when there is a suspicion or confirmation of psychological distress [50].

Our findings on substance use in pregnancy indicate lower rates compared to Belgian [51] and French [52] studies but closely align with research from the Netherlands [53]. Additionally, similar to a Dutch study [53], action was taken for more than half of the pregnant women who consumed substances. Regarding interpersonal violence, our data reveal lower prevalence rates than other studies, except for past violence [51, 54]. However, our findings align with a Dutch study that used similar methods, namely psychosocial screening by healthcare providers [55].

Overall, compared to controlled simple intervention studies, where uptake can be measured as a proportion of predefined opportunities to interact with the system, our results demonstrate promising perspectives for the uptake of a complex CDSS innovation in real-life context. This is reflected by sustained use within settings, high completion of screenings, and frequent care actions after positive screening results.

Taken together, these findings—including the increasing number of participating settings and active users over time, high progression through the platform workflow, high screening and action completion rates, timely initiation of screening, and indications of collaboration between care providers—suggest that the platform appears to be integrated into routine care processes within participating settings.

Limitations and strength

To date and to our knowledge, there has been no reported evaluation of CDSS uptake addressing psychosocial vulnerabilities during pregnancy. This is the first thorough study that evaluates a non-medical CDSS uptake within antenatal care. However, there are **limitations** to this study. Due to a still ongoing large-scale national rollout

of the CDSS BIB-Pro platform, our results do not yet reflect the entire Belgian care providers' uptake and the pregnant population. Moreover, as this is not a controlled study but instead an observational study in real-life settings, and data were collected from platform usage, we were unable to calculate absolute uptake because denominator data on all eligible users and pregnancies were not available. The number of users and files depends on a setting's implementation process, such as platform integration possibilities in EHR software systems, Data Protection Officer approval, agreements established within a setting, the extent to which users engage with the platform and which pregnant women are targeted for its use. Consequently, uptake-results in a real-life setting may appear sub-optimal but could in reality be optimal based on the organisational agreements established. Therefore, future evaluation of CDSS uptake and in-depth contextual evaluation to understand the observed uptake, including variations between medical and social care settings, will be performed.

When it comes to the data output's analyses, the data does not capture the whole pregnant population. Moreover, data input constraints may impact the results extracted from the BIB-Pro platform. Constraints include underreported information during one-on-one reporting with a care provider [56], concerns about stigmatisation affecting both parties [57], potential misinterpretation or issues related to wording [58], women not seeking help, especially regarding mental health [49, 59], women's low expectation of the perinatal care [51] or care providers' lack of time [23]. Nevertheless, the benefit of conducting face-to-face interactions, facilitated by the utilisation of a questionnaire or support system, leads to increased detection, relationship of trust, the ability to capture non-verbal cues and the incentive to offer help [60].

Moreover, when it comes to comparing our data with other studies, the differences observed can be attributed to population variations and variances in data collection methods. The latter includes database retrieval, types of questions, and self-reporting versus one-on-one questioning. Data retrieved from a digitalised platform minimises the likelihood of erroneous data transfer or collection, as opposed to handwritten data collection [61].

The fact that we could evaluate the uptake of a unique CDSS supporting integrated psychosocial care in pregnancy is a major **strength** of this study. We analysed various aspects of uptake and captured users' activity from implementation start until data extraction, thereby addressing the lack of studies reporting CDSS uptake [5]. A strength of this study is that user engagement was assessed using system use metrics (e.g., number of users and activities within the platform), an important approach to measure engagement according to a

systematic review [27]. However, behavioural metrics alone may not fully capture user experience, as frequent interactions can reflect either positive engagement or difficulties navigating the system [27]. To complement these objective measures, our previous publication explored users' perceptions of the platform through survey data [26].

Furthermore, a notable strength of this study is the analysis of a large-scale CDSS implementation covering more than one region and different real-life settings. The first results are promising since from the early start onwards, care providers in real-life settings across the country are open to using the shared BIB-Pro platform. Moreover, our government is taking initiatives to provide reimbursement for antenatal psychosocial screening, which might positively influence uptake. Further analysis will be performed to comprehend the factors influencing the platform's usage. Uptake can be influenced by individuals' behavioural changes, acceptance of technology, and the contextual factors surrounding the platform's implementation. Therefore, our next step will be to explore the contextual factors and strategic approaches necessary to adopt this CDSS, utilising implementation frameworks as guiding tools. In addition, the BIB-Pro platform offers the potential to analyse national and even international antenatal data, facilitated by its multilingual capabilities and user-friendly interface.

Finally, the platform's ability to conduct multilingual screening and capture data from various care providers in primary and hospital care settings contributes to an enriched and diversified dataset. The platform is a support to the needs of care providers in practice that are aiming to detect as early as possible psychosocial indicators that may require attention, share information, and offer integrated care [3]. It might also provide inspiration to policymakers internationally.

Conclusion

This observational cross-sectional study demonstrates a favourable overall uptake of the BIB-Pro platform, an innovative shared CDSS in antenatal care, by early adopters in real-life settings. The platform is consistently utilised, particularly in medical settings offering care to primarily pregnant women and where organisational facilitation, such as EHR integration and personnel support are ensured.

The action-oriented use of the platform, reflected in the completion of psychosocial screening and the registration of follow-up actions after indicator identification, suggests that the platform is used in a structured manner and can be integrated into routine care processes within participating settings.

The platform's usage provides us with a more comprehensive and uniform representation of antenatal

psychosocial indicators identified during pregnancy and available interventions in our country. This fills a gap in the lack of data on psychosocial screening and the absence of data on action reporting upon indicator identification.

Further analyses, including contextual assessments and longitudinal user uptake studies, are imperative for a comprehensive understanding of evaluating a CDSS comprising a complex intervention. This involves screening for diverse aspects of psychosocial vulnerabilities, using different care pathways, and engaging multiple stakeholders across sectors, all within real-life settings.

Abbreviations

CDSS	Clinical Decision Support System
BIB-Pro	Born in Belgium Professionals
EHR	Electronic Health Record
SSIN	Social Security Identification Number
AUI	Alternative Unique Identifier
IQR	Interquartile Range
BIS	(Not spelled out in the text; context suggests it refers to a number for non-Belgian citizens without a valid Belgian eID and not domiciled in Belgium)
UZ	Universitair Ziekenhuis (University Hospital)
B.U.N.	Belgian Unique Number (in research ethics context)
GAD-2	Generalized Anxiety Disorder-2 (screening tool)
COPE	iCOPE (not spelled out, likely related to a digital tool; stands for Interactive Clinician-Operated Perinatal Evaluation in other literature)
GyPsy	(Not spelled out; a name for a tool/platform for psychosocial screening)
MatChat	(Not spelled out; a name for a tool/platform for psychosocial screening)

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Author contributions

VdBS was responsible for the back-office data collection and provided the dataset. AK handled the data analysis, interpretation, and the manuscript

writing. BK assisted with data interpretation and manuscript writing. All authors contributed to, read, and approved the final manuscript.

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Data availability

The datasets generated and/or analysed during the current study are not publicly available due to privacy restrictions but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The Ethics Committee of UZ Brussels approved this study (B.U.N. 143201941861) on December 18, 2019. Institutions and partners agreeing to the platform's implementation provided an informed consent for data collection and analysis as part of the evaluation process by signing the implementation contract. All procedures were carried out in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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