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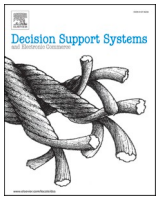

Prioritising national healthcare service issues from free text feedback – A computational text analysis & predictive modelling approach

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ABSTRACT

Patient experience surveys have become a key source of evidence for supporting decision-making and continuous quality improvement within healthcare services. To harness free-text feedback collected as part of these surveys for additional insights, text analytics methods are increasingly employed when the data collected is not amenable to traditional qualitative analysis due to volume. However, while text analytics techniques offer good predictive capabilities, they have limited explanatory features often required in formal decision-making contexts, such as programme monitoring or evaluation. To overcome these limitations, this study integrates computational text and predictive modelling as part of a Computational Grounded Theory method to determine the effect of quality gaps in care dimensions and their prioritisation from free-text feedback. The feedback was collected as part of a national survey to support decisions on continuous improvement in Maternity Services in Ireland. Our approach enables (1) operationalising the service quality lexicon in the context of maternity care to explain the effect of quality gaps in care dimensions on overall satisfaction from free-text comments; and (2) extending the service quality lexicon with two organisational and political decision-making concepts: "Salience" and "Valence", for prioritising perceived quality gaps. These methodological affordances enable the extension of service quality theory to explicitly support the prioritisation of improvement decisions which before now required additional decision frameworks. Results show that tangibles-, process-, and reliability-related care issues have the highest importance in our study context. We also find that hospital contexts partly determine the relative importance of gaps in care dimensions.

1. Introduction

The quality of healthcare services in general can be measured by the extent to which the care provided is person-centred [1]. This includes treating service users with respect and dignity while being responsive to their individual preferences, needs, and values [1]. Over the years, patient experience surveys have become a popular approach for evaluating the extent to which care is patient-centred. Although most patient experience surveys are based on carefully designed standardised survey instruments, free-text responses are increasingly captured in these surveys [2]. In general, free-text feedback provides patients, service users, and carers with the opportunity to freely express their opinions on care-related matters that may not have been covered in closed survey instruments.

Harnessing large amounts of textual feedback to produce novel and actionable insights, particularly in formal decision-making contexts is challenging [3,4]. Computational techniques afford automated analysis of large textual data [5,6] with high predictive accuracy in many practical applications. However, their weak interpretability and explanatory capabilities limit their use in formal decision-making contexts [7] such as in programme monitoring and evaluation. In these contexts, policy-makers will trade-off model accuracy for model interpretability and

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explainability, and demand methods characterised by effective research design, underpinned by substantive theory [8] that can also withstand public scrutiny [9]. In addition, decision contexts associated with policy or program design, monitoring and evaluation require *theories of change*. A Theory of change (ToC) describes the hypothesised links between a programme's activities and its anticipated outcomes [10]. ToC describes both the pathways from activities to impact and the set of causal assumptions behind the links in pathways [11]. Thus, computational techniques employed in this decision context are expected to provide inputs for building and updating ToCs.

There are however emerging efforts in building theories from predictive models (i.e. inductively from data), for the purpose of explanation, to overcome this shortcoming described above [12]. Emerging methods such as computational grounded theory [13] and data-driven computationally intensive theory development [14] in particular, offer valuable high-level methodological frameworks for integrating computational text modelling methods with rigorous traditional qualitative methods such as grounded theory, to extract novel theoretical and practical insights inductively from large textual datasets. Yet some other recent works [6,15,16], demonstrate how computational text analytics or big data approaches [7] can be applied to produce theoretical contributions without explicitly developing theories.

In this study, our interest lies in approaches that directly afford substantive theory building, inductively from textual data, as input for developing the theory of change to improve a National Maternity programme. CGT by design supports theory development from textual data. CGT explicitly provides a "*lexical framing*" step which entails the use of theoretical or "pre-theoretical" vocabulary or lexicons for framing the data when constructing substantive theories [14]. This is part of an overarching iterative process of inductive theory building in the Glasserian and Straussian tradition of the Grounded Theory method [17]. We build on ideas from computational grounded theory [13] and methods for inductive theory development from large textual data [14,18] to implement the three-step process of "*discovery, measurement & analysis, and inferencing*" described in [19] for rigorously analysing text. One of the fundamental principles for text analysis offered in [19] and consistent with frameworks elaborated by [13,14] is "*that text analysis does not replace humans – it augments them*". Thus, while complete automation of the text analysis pipeline is feasible, having a "human-in-loop" for sensemaking, interpretation, categorisation, and iterative refinement of patterns discovered in text, characteristic of qualitative research, is necessary for generating evidence fit for supporting formal decision-making. Having human-in-the-loop does not prevent the scalability of the approach as human efforts are related to the review of emergent care themes and selected representative documents.

We analysed free-text feedback collected as part of a national survey on maternity services to provide additional insights to the closed-form responses collected in the same survey, as part of efforts to support decision-making for continuous improvement in the Irish Maternity Services system. Although several studies have examined the determinants of patient satisfaction, results are still inconclusive and contradictory, thus making generalisation difficult [20]. This could be attributed to the multiplicity of theoretical frameworks [20] and the use of domain-specific measures [21]. In addition, the set of factors influencing patient satisfaction the most, are contestable [22]. In general, the determinants of patient satisfaction and their relative importance are contingent on patient and hospital characteristics [23]. *Thus, we aim to establish, for our study demographics and maternity services context, (1) how quality gaps in different aspects of maternity services might impact overall satisfaction; and (2) how the improvement in service quality gaps can be prioritised from a service user perspective. We also investigate how the hospital context - specifically the level of neonatal care provided by the hospitals, affects both the impact of quality gaps and their prioritisation for action.*

Our analysis of service quality gaps revealed additional dimensions that are peculiar to maternity care, in addition to the traditional dimensions associated with the well-known SERVQUAL model, thus producing a more robust set of determinants of patient (and specifically maternity care) satisfaction as advocated in [24]. The importance of service quality gaps was determined by operationalising the theoretical concepts of "*Valence*" and "*Salience*" associated with political and organisational decision-making. Valence describes consensual issues on which there is agreement e.g., better healthcare is desirable [25,26]. The concept is also related to the perception of an issue as being positive or negative [27]. The salience of an issue is the importance, or level of concern attached to an issue, by individuals or a group [28]. The extension of service quality models with prioritisation concepts enables the integration of service quality gap importance into our measurement framework as prescribed in [24]. This allows for a better understanding of the differences in the relative importance of service dimensions across different models and studies [24]. Past studies on SERVQUAL addressed prioritisation using approaches such as multicriteria decision procedures [29], Importance-Performance Analysis [30] and the KANO model [31], all of which are largely based on data collected through SERVQUAL questionnaires. While these approaches are effective they require either specially designed survey instruments (e.g. KANO), or eliciting additional inputs from experts or end-users on the weights and perceived relative importance of each quality gap. Our approach attempts to implicitly capture these preferences as part of the valence and salience constructs, thus enabling us to directly establish the importance of gaps in the data without requiring additional information.

We believe our work makes some important contributions. First, the work contributes to the emerging body of literature on computational grounded theory and related methods by offering operationalisation, and practical insights on the methodology, in a national programme monitoring context. Second, from a theoretical perspective, the study extends the lexicon of SERVQUAL to explicitly support the prioritisation of quality gaps in service dimensions from textual feedback, based on the decision concepts of valence and salience. We also extended the SERVQUAL dimensions with additional context-specific service quality dimensions for the maternity care domain. Thirdly, from a policy and practice perspective, the study provides rigorous evidence for prioritising national healthcare issues from service users' feedback, based on the concepts of salience and valence, to underpin the design of ToC for improving maternity care.

The structure of this paper is as follows. Section 2 provides a literature background on patient and maternity care experience. The study context is discussed in Section 3 while the methodology adopted in this study is presented in Section 4. The results and findings are presented in Section 5 and discussed in Section 6. We provide some concluding remarks in Section 7.

2. Theoretical framework

2.1. Maternity care experience

Patient care experience encompasses "the range of interactions that patients have with the healthcare system, including their care from health plans, and from doctors, nurses, and staff in hospitals, physician practices, and other health care facilities" [32]. It is a complex, multidimensional phenomenon shaped by a confluence of factors from patient expectations and satisfaction to the patient-centricity of service as an overall evaluation of patient experien**ce** [21,33]. While a hospital cannot guarantee patients' experiences, they can create the care conditions under which an individual is more likely to have a unique and positive experience.

SERVQUAL is one of the most established models for evaluating service quality. The model comprises five dimensions including Tangibles, Responsiveness, Reliability, Assurance, and Empathy [34]. Many studies have confirmed the validity of using SERVQUAL for measuring service quality in the healthcare domain [35] and have investigated the core determinants of patient satisfaction. While the core determinants appear to vary with the nature of patient care, *Assurance*, *Empathy*,

Tangible dimensions appear often as key determinants. In the context of acute care, *Physical comfort (Tangible)*, *Emotional support* (*Empathy*) and *Respect for patient preferences* (*Empathy & Assurance*) were found to be major determinants of patient satisfaction [36]. In a more general study spanning outpatient and acute care contexts, *Assurance & Empathy*, *Reliability* and *Tangible* dimensions of care were the strongest determinants of patient satisfaction [37]. However, for community care, the *Process of care* was identified as a determinant of patient satisfaction [38]. In addition, patient and hospital characteristics (e.g. demographic characteristics, type of treatment received and organization of care) were found to be determinants of patient experience and satisfaction in fertility treatment [23].

Despite the widespread use of SERVQUAL, it is not without its limitations, particularly where capturing all the dimensions of patient care and offering additional constructs [39] is concerned. These additional dimensions include Process [40–43]; Communication [44–48]; and Pain Management [49]. In addition, domain-specific measures of patient experience have been reported in the literature. For instance, five determinants for patient care experiences including the experience of illness; the patient's subjective influences; quality of healthcare services; health system responsiveness; and the politics of healthcare were determined [21]. Additional service dimensions include access to information, quality food [50], the physical environment in which the care is received, the outcome of care [20], medical personnel attitude and interpersonal skills, access to emotional support, facility cleanliness and privacy, and convenience [51,52]. Finally, accessibility from a financial perspective plays a role in determining patient satisfaction with care, as does continuity of care [20].

Considering maternity care; a unique aspect of healthcare, available studies have shown that some of the factors that shape maternity care experience are similar to those that determine general patient care experiences. These include privacy during examination, the presence of companionship/emotional support, and the general healthcare environment (including the freedom of movement on the ward during the labour process) [53]. There have been studies exploring socio-demographic factors and their resultant impact on women's expectations, and subsequently, their perceptions of care [54]. For instance, a study focusing on women's maternity care experiences in Italian maternity hospitals found that satisfaction was generally higher among foreign women coming from non-Western countries and among highly educated women [54]. Another potential factors found to impact maternity expectations, and consequently, healthcare experiences, is culture – access to culturally appropriate care as a necessity for delivery of high-quality maternity care [55,56] and in healthcare settings generally [57]. *Process of care* was the core determinant of women's satisfaction with maternity services [58]. One of the specific factors of maternity care experiences is the involvement of the partner during birth [59]. Access to anaesthesia during delivery is identified as a determinant of maternity care experience while inadequate or delayed anaesthesia is associated with dissatisfaction during obstetric care – a domain-specific determinant of the maternity care experience [60]. Relatively few studies on maternity care experience have used SERVQUAL-based measures. There are some exceptions [61] that examine service quality gaps using the SERVQUAL dimensions and relate these gaps to women's satisfaction [62]. A gap in the *Empathy* dimension was found to have the strongest correlation with childbirth satisfaction in particular [62]. Overall, from the available studies, the core factors associated with women's satisfaction in maternity services include privacy, access to culturally appropriate care, access to anaesthesia and the process of care. These factors are related to SERVQUAL dimensions of *Assurance, Empathy, Reliability* and *Process of Care (one of the domain-specific extensions)*. There is also some evidence [45] that socio-demographic factors including maternal factors (number of children, age, marital status) and socio-economic factors (e.g. wealth and education status) may affect the expectations of maternity service users [63].

A limited number of studies have explored the impact of the *hospital context* on patient experience and the elements that influence healthcare service satisfaction [64,65]. Extant research has examined factors including the effect of hospital size (staff size and bed capacity) [66,67], and receiving care in private versus public hospitals [68–70]. The effect of the hospital's speciality [71,72], academic versus non-academic hospital status [73–76], environmental factors of the hospital rooms (e.g. room types, distance to the nursing station) [77], while urban versus rural hospital locations [78,79] have also been studied. The findings from these studies suggest that various hospital characteristics have potential effects on quality of care and patient satisfaction. However, these findings are hard to generalise due to inconsistencies in the type of effects [64,76]. The heterogeneity in theoretical frameworks, study designs, and measurements makes the results from these studies incomparable [20]. In addition, the National context (i.e. cultural environment) of healthcare facilities is a potential source of such inconsistency [20,64]. However, studies examining the effect of hospital contexts on the quality of maternity care and women's satisfaction are limited. In particular, the effect that different levels of neonatal care provided by maternity hospitals, have on the perceived quality of maternity care and overall satisfaction, are yet to be studied. Neonatal care is a critical aspect of the birthing stage of maternity services [80].

2.2. Prioritising issues in decision-making for care improvement

While there have been several studies, albeit inconclusive, on key determinations of patient satisfaction, a few studies have also attempted to explicitly prioritise these service quality dimensions using techniques like multicriteria decision procedures (MCP) [29], Importance-Performance Analysis (IPA) [30] and the KANO model [31]. Although these techniques are effective, they require specially designed instruments (e.g. in the case of the KANO model) or require additional inputs from end-users and domain experts on relative preferences and weights to be assigned to the different service quality dimensions (e.g. in MCP and IPA). For our decision context – how to improve a national government programme, we seek an approach that enables prioritisation of quality gaps in maternity services based on two key political and organisational decision-making concepts - valence [27] and salience [28] directly from the textual feedback without additional information. We expound on these two key concepts below.

2.2.1. Issue salience

The salience of an issue is the importance attached *to an issue* by individuals or a group [28]. Salience is considered an explanatory concept that contributes positively to overall prediction, yet its measurement can be challenging [81]. There is an increased use of issue salience in recent years particularly in the field of politics [28]. While issue salience can be relatively stable it can evolve and adapt overtime as different issues come into prominence [82]. There are two kinds of issue salience – retrospective and contemporaneous; retrospective salience is determined by expert evaluations made well after the date of the decision while contemporaneous salience is one which identifies whether a particular issue is important at the present time [83]. Although, the causes of variation in issue salience is under-theorised, rarely tested, and its antecedents remain relatively unknown, it is recognised as offering impressive predictive power [28]. In the context of hospital care improvement, we employ the concept of salience to reflect the importance of a particular care issue or theme from the *service user perspective*. Salient care issues must satisfy two key criteria – (1) have relatively high impact on the patient experience or overall satisfaction (positively or negatively), so that the stronger the effect, the more salient the issue is; and (2) must also be consensual with a relatively high number of users identifying with the care issue. In addition, salient care issues are assumed to be both technically and organisationally feasible. Consequently, *addressing salient care issues should produce relative major changes in patient experience and satisfaction*. Thus, care issue salience provides a basis for prioritising improvements to quality gaps in care dimensions.

We provide a conceptual framework and operationalisation of care issue salience in Section 4.

2.2.2. Issue valence

Valence is the emotion attached to an issue, or the strength of the sentiment an issue evokes from individuals or groups [27,84]. Valence describes consensual issues on which there is an agreement [25,26]. Valence theories have grown in importance since the 1980s and are often utilised within the politics and electoral behaviour literature as a means of explaining voter choice [85]. Like salience, valence factors can change over time due to shifting responses to presenting issues [85]. It is argued that political parties adopt valence discourse in response to overwhelming uncertainty [25]. When considering issue valence, it is important to consider positive versus negative valence; framing an issue positively or negatively impacts how a person responds to the issue [27]. For example, when managers have a low capability to address a situation, they invest more resources in a positively framed, rather than a negatively framed, issue; conversely, when feeling highly capable they are more likely to invest more resources in a negatively rather than positively framed issue [27]. This is important to note when presenting the results from this study to managers and policymakers. Decisions often are not rational or mechanical they can be loaded with emotionality [84]; within a hospital setting issues of seemingly minimal importance or relevance to an individual's health and well-being can become amplified and all-encompassing. Patients are out of their routine, they are in a relatively fragile physical state (heavily pregnant or post-natal), and experiencing a life-altering moment; thus, emotions and sentiments are important concepts to explore when analysing patient care experience. We conceptualise both the valence and salience of care issues as determinants of their importance and basis for prioritisation for improvement in Section 4. This way, we extend the SERVQUAL model to support prioritisation of issues in decision making related to improvement of care.

3. Study context – Irish maternity service

Ireland's Health Information Quality Authority (HIQA) has statutory responsibility for setting healthcare safety and quality, social services standards, monitoring children's services, and governing health information. HIQA's mandate extends across a range of public, private, and voluntary services. HIQA launched a national report outlining a set of "National Standards for Safer and Better Maternity Services" in 2016 [86]. The purpose of the report and the subsequent development of standards was driven by an impetus to address "service deficits and failings" that "undermined confidence" in maternity services. The National Maternity Strategy [87] identified four strategic priorities including (1) adopting a health and wellbeing approach to ensure babies get the best start in life; (2) providing women with safe, high-quality, consistent, woman-centred care; (3) facilitation of a woman's choice in pregnancy and birth, and (4) appropriate resourcing and governance of maternity services. As a means of fulfilling these strategic priorities, National Standards were developed along eight thematic dimensions centred on safety, quality, capacity, and capability improvement. These are outlined in detail in Table 1 below (adapted from HIQA's National Standards for Safer and Better Maternity Services, 2016 [86]).

Following the launch of HIQA's National Standards for Maternity Care in 2016, the National Maternity Experience Survey (NMES) series [88] was first deployed to assess women's maternity care experiences and ultimately to better understand how maternity services are improving the safety, quality, capacity, and capability of the care they are providing to women in the Irish maternity hospital and care settings. The survey consists of 8 parts (maternity care aspects) and contains 65 closed- and 3 open-ended questions (women experience indicators). The first seven parts are designed to collect data on women's experiences through the consideration of the following maternity care aspects: (1) Care while pregnant (Antenatal Care), which contains (17 questions); (2) Care during labour and birth (10 questions); (3) Care in hospital after birth (9 questions); (4) Specialised care for the baby (3 questions); (5) Feeding the baby (5 questions); (6) Care at home after birth (14 questions); (7) Overall Care (2 questions), including overall rating of the women's care experience, and (8) Other section, includes 3 open-ended questions. The last part of the survey is devoted to collecting the demographic data of the participant, such as (i) the woman's date of birth; (ii) the number of babies that a woman previously gave birth to; (iii) ethnic group; (iv) county of residence (26 counties); and (v) whether the woman had mental health problems on a long-term basis (disability). In this study, the overall rating of the *patient's care experience* was considered as a proxy of patients' overall *service satisfaction rating* [33].

Table 1
Strategic priorities National Standards.

Four Safety and Quality Themes	
Theme 1. Person-centred Care & Support	Service that places the woman and her baby at the centre of delivery care, including access, equity, and protection of rights
Theme 2. Effective Care & Support	Service that delivers the best achievable outcomes for women and their babies, including service design and sustainability
Theme 3. Safe Care & Support	Service that avoids, prevents, and minimises harm to women and their babies and learns with things go wrong
Theme 4. Better Health & Wellbeing	Service that works in partnership with women to improve their health and wellbeing and that of their babies
Four Capacity and Capability Improvement Themes	
Theme 5. Leadership, Governance & Management	Service has arrangements that support clear accountability, decision-making, and risk management; in addition to supporting the fulfilment of strategic, statutory, and financial obligations
Theme 6. Workforce	Service has procedures to support planning, recruiting, managing, and organizing an appropriately staffed and competent workforce
Theme 7. Use of Resources	Service uses resources effectively and efficiently to deliver best possible outcomes for women and their babies
Theme 8. Use of Information	Service actively uses information as a resource for planning, delivering, monitoring, managing, and improving care

4. Methodology

We build on the Computational Grounded Theory (CGT) [13] and methods for inductive theory development from large textual data [14,18,89] following a three-stage analysis framework [19]. CGT combines human expertise in interpretation with computational analysis for a consistent reproducible grounded theory approach [13]. It inductively derives themes from data, offering a theoretical insight into the studied phenomenon. The CGT process in [14] merges manual grounded theory methods with automated computational discovery. The manual effort in CGT mainly hinges on inferencing depth and theory-building, not on dataset size. Thus, having human-in-the-loop does not prevent the scalability of this approach as the human effort is at most a linear function of the number of topics or themes generated from the dataset. Our approach aligns with the three-phase text analysis framework: Discovery, Measurement & Analysis, and Inferencing [19].

Our text analysis framework enables the study of secondary and trace data without apriori research questions or hypotheses. The Discovery phase aims to develop research questions after initial data exploration [19]. Five key theoretical concepts described in Section 4.1 below guided our exploration of the dataset and the development of our research questions.

4.1. Discovery

4.1.1. Sampling and data collection

The area of investigation and data for this study comes from the NMES conducted by the National Care Experience Program (NCEP)[1] in Ireland [88]. The target group for this study are women aged 16+ years who have recently given birth in one of Ireland's 20 maternity care services (comprised of 19 public hospitals and a range of National Home Birth Services). Hospitals providing maternity care services in Ireland provide different levels of neonatal care. The three levels of neonatal care are differentiated by three key elements: *infrastructure, staffing, and operational systems* [90]. Level 1 (or *local* units) maternity hospitals provide routine care for term infants and special care for infants of 32 weeks gestation and above, with capacity for infants of 30–31 weeks. Level 2 (or *regional* units) hospitals care for infants over 27 weeks gestation, providing special, high-dependency care, and short-term ventilation in addition to routine services. Level 3 (or *tertiary* units) hospitals provide comprehensive care for both term and pre-term critically ill infants, and deal with a significant number of cases involving low birth weight infants and those requiring assisted ventilation [91].

The survey was conducted digitally (online) and physically (paper) in February and March 2020 and consists of 65 closed- and 3 open-ended questions. The survey response rate is 3206 out of 6357 (50%). However, we note that two of the responses were very sparse. The respondents' demographic information is presented in Table 2. The largest cohort of women is between the ages of 30 and 39 (72.36%). Most respondents are white (94.1%) and only 18.22% of respondents have one or several disabilities from 11 types listed in the survey.

For this study, we used an integrated dataset, containing the following three data parts: Firstly, 2615 anonymous *free-text responses* to the question "Was there anything that could be improved?". After further pre-processing, including text cleaning and converting into STM corpus format, we had a final dataset of 2470 *comments*. Secondly, 37 indicators (from which 11 constructs were developed) were selected from the NMES *closed-ended questions.*[2] The closed-ended questions measure (i) women's care service experience using a mix of 3, 4, 5, or 6-point scales; and (ii) their overall *rating* of patient experience, assigned by women (10-point scale). After combining two parts of our dataset by matching the unique IDs of anonymous respondents, a total of 2246 comments were taken into consideration for further analysis. Finally, the dataset was complemented with data on Neonatal Unit levels corresponding to each respondent's hospital.

Table 2
Demographics of respondents ($N = 3206$).

Characteristic	Participant	
	Number	%
Age group (years)		
<25 years	155	4.84
25 to 29 years	451	14.07
30 to 34 years	1173	36.60
35 to 39 years	1146	35.76
40 and above	280	8.74
Ethnic group		
White	2969	94.10
Minority (Black or Black Irish, Asian or Asian Irish, or Other, including mixed group/background)	186	5.90
Disability		
Yes	584	18.22
No	2622	81.78
Levels of maternity services		
Local neonatal unit	895	40.17
Regional neonatal unit	388	17.41
Tertiary neonatal unit	945	42.41

[1] The National Maternity Experience Survey (NCEP) is a partnership between the Health Information and Quality Authority (HIQA), the Health Service Executive (HSE) and the Department of Health

[2] An overview of constructs development is provided in Web Appendix A

4.1.2. Conceptualisation

The conceptualization step is crucial for crafting research questions, selecting key measures, and setting inference goals. Our study aims to identify key care issues from free-text feedback to enhance maternity services. We develop a conceptualisation model that extends service quality (SERVQUAL) lexicons with the theoretical concepts of valence and salience to establish the relative importance of care themes and dimensions for prioritisation. Fig. 1 shows our conceptual model, which uses five key theoretical concepts: (1) *Quality Gap in Care Dimension* – the relative prevalence of associated themes; (2) *Effect of Care Dimension* – the aggregate effect of gaps in associated care themes on overall satisfaction; (3) *Negative Affect of Care Dimension* – the aggregate negative sentiment of associated themes; (4) *Salience of Care Dimension* – determined by the quality gaps and corresponding effect of associated themes; (5) *Valence of Care dimension* – determined by the quality gaps and negative affect of the associated themes; (6) *The importance of a care dimension* - determined by its salience and valence.

4.1.3. Research questions

Guided by our conceptualisation and overall research objective, the study seeks to address the following research questions in the context of maternity services:

RQ1. How do quality gaps in the different care dimensions impact service satisfaction?
  RQ1.1 How are these impacts affected by the hospital context?
RQ2. How should improvements in care dimensions be prioritised from a service user perspective?
  RQ2.1 To what extent does hospital context affect this prioritisation?

Hospital context has been found to affect the impact of perceived quality gaps in patient care [92,93]. We are interested in how the level of neonatal care provided by maternity hospitals could affect the impact of quality gaps and their relative importance for improvement. We operationalise these concepts below.

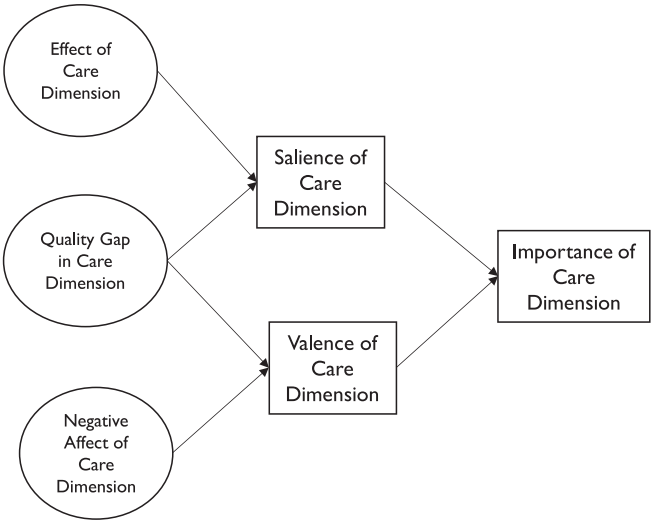

Fig. 1. Conceptual model for identifying important care dimensions for prioritisation.

4.2. Measurement and analysis

This phase comprises two key steps — *Synchronic analysis* and *Lexical framing*. The synchronic analysis involves categorising data using concepts and relating them while lexical framing associates these categories with lexicons or constructs drawn from relevant theoretical models [14].

Synchronic analysis—Step 1a: Generating themes—we employed structural topic modelling (STM) for extraction of the latent topics (themes) from free-text responses. STM is an extension of the LDA known unsupervised learning-based text analysis framework [94], that is widely adopted in customer experience studies [3,95].

At this step, *firstly*, to determine the optimal number of themes, we built STM models ranging from 10 to 100 topics. Based on normalised exclusivity and coherence scores, we determined that the 65-topic STM model as the optimal model [4,39,95]. *Secondly*, we built the STM model to produce the topic-word distribution; document-topic proportions; top-weighted keywords; and the set of documents, mostly associated with this topic. *Thirdly*, we labelled the topics iteratively as follows: (1) four experts independently labelled the topics based on top-weighted keywords; (2) experts discussed the labels and resolved differences in labelling; (3) experts independently refined topic labels based on the computationally guided deep reading of the top 20 most representative comments within the topics; (4) experts discussed to align the refinements done. We identified seven semantically related topics, which we then combined by renaming and aggregating their respective topic proportions; and (5) experts agreed on the final set of topic labels and described the topics. Domain experts (from healthcare, text analytics, linguistics, and the social sciences) were involved in all steps of the study. *Fourthly,* for each topic or care theme, we determined its *prevalence* as the total document-topic proportion over all free-text responses. The prevalence of a topic is a measure of the *quality gap* associated with the care theme. *Finally*, for each of the three hospital contexts or *neonatal unit levels,* related subsets of the topics and associated *quality gaps* were computed.

To explore how these quality gaps vary by different sociodemographic groups, we designed three separate STM models using women's *Age*, *Ethnicity,* and *Disability* demographic variables as covariates. For this, each group was dichotomised based on the NMES codebook as follows: (1) *Age* – *Younger* women (under 35 years age) and *Older* women (35 years and over); (2) *Disability* – Women *With* and *Without disability*; (3) Ethnicity – *White* women and women from *Other ethnic* groups. The outcome of those models includes demographic-based (i) topic-words distribution and (ii) document-topic proportions. Using STM model covariate analysis outcomes we computed the quality gaps for the different care themes (i.e. the topics) across different service user cohorts.

Synchronic analysis—Step 1b: Estimating the effect of quality gaps on satisfaction —we employed the random forest (RF) prediction models to estimate the effect of (i) constructs developed from closed-ended responses, and (ii) the quality gaps associated with care themes estimated above. Four RF models (one for the whole dataset, and *three* for each subset, related to each neonatal unit level) were built as follows: (i) the overall satisfaction is the *dependent* variable; (ii) average scores of the indicators included in each factor related to closed-ended questions and quality gaps (document-topic proportions θ) for the care themes were chosen as *predictor* variables; (iii) training and test subsamples were drawn from the target dataset in a 70:30 ratio. The scale and distribution of dependent and independent variables are provided in Web Appendix G.[3] For RF analysis, RF tree methods (number of trees = 300; the number of variables tried at each split = 3) are used.[4] To determine the *estimated effect* of gaps associated with care themes and the factors developed from closed-form questions on overall service satisfaction, the Gini Importance Indices were computed.

Synchronic analysis—Step 1c: Estimating the degree of negative affect associated with the care themes —we employed six sentiment tools[5] to calculate the sentiment scores (positive or negative) for the free-text responses dataset. We excluded two of the six sentiment lexicons (Jeff Gentry's Twitter and NRC) due to their low cross-correlation coefficients, using 0.5 as the threshold. The sentiment score produced by the remaining four libraries was normalised from 0 (most positive) to 1 (most negative). Finally, the geometric mean of the *sentiment scores* for the top-5 comments (i.e., comments with the highest topic proportion or most representative for each care theme) was calculated to estimate the negative affect for each care theme. For each of the three *neonatal unit levels,* related the *affect* for the subset of care themes were also calculated.

Synchronic analysis—Step 1d: Estimating Valence and Salience of care themes—we employed the following three steps. *First*, the values of estimated themes' *quality gaps*, *effect*, and negative *affect were* normalised to values between 0 and 1. Thus, issues with high-quality gaps, effect and negative affect will have values closer to 1. *Second*, we computed the *salience* of a care theme using its quality gap and effect while its *valence* was computed as a function of its quality gap and affect. *Third*, to calculate the relative salience and valence of the themes, we compute the Euclidean distance of each theme's salience and valence values from the maximum possible value for both measures (1,1) corresponding to our so-called most *critical* care theme.

Lexical framing—Step 2a: Mapping care themes to healthcare service quality theoretical constructs—we manually mapped latent themes to SERVQUAL-related constructs or *care quality dimensions*. SERVQUAL is the most established theoretical framework for measuring service quality. Our mapping is realised by three independent domain experts with a fourth expert consolidating. For this, the researchers: (i) carried out an in-depth literature review of studies on service quality assessment and systematically documented existing constructs related to SERVQUAL and their dimensions; (ii) topics labels, topics descriptions, and 20 of the most representative comments of each topic were carefully studied and compared with the list of SERVQUAL constructs and their items found in the literature; (iii) experts independently mapped the themes to the SERVQUAL constructs based on the *similarity* between the care theme and the constructs, with statements to justify the assignment. Where a theme cannot be mapped to existing constructs, *new constructs were created*; (iv) using a quasi-Delphi approach, experts met to integrate and *agree* on the mappings. This process produced: (i) a final set of *care themes*; (ii) importance-related attributes of the care themes – quality gaps, effect, affect, valence, and salience; and (iii) care dimensions (as categories) comprising care themes.

Lexical framing—Step 2b: Mapping themes to National Standards for Safer Better Healthcare—we manually mapped the latent topics to the National Standards thematic areas (Table 1) based on HIQA reports [86] to frame the emergent care themes using policy-relevant lexicon. For this, (i) the National Standards thematic areas, their items, and descriptions, were carefully studied; then four experts (ii) independently mapped each of the topics to one of the National Standards; (iii) documented this process and provided evidence to justify their individual choice; and (iv) met to integrate and agree on the final mappings.

4.3. Inferencing

The goal of this stage is to draw inferences from our measurements of the various concepts detailed in the preceding section and their analysis. Thus we generate propositions based on the patterns resulting from our analysis [14].

Inferencing - Step 3a: Predictive Inferencing. This step allows us to draw inferences on (1) care themes with the largest quality gaps, and with the

[3] Web Appendix G

[4] randomForest package; randomForestExplainer package

[5] Jeff Gentry's Twitter package; NRC Emotion Lexicon; Syuzhet Package; Bing lexicon; AFINN lexicon; VADER sentiment analysis library [112]

greatest impact on overall satisfaction; (2) the effect of hospital care contexts on gaps and their impacts; and (3) prioritised care themes for improvement, i.e. care aspects of high salience and valence.

Inferencing - Step 3b: Inductive theory generation. In this step, we provide propositions that capture emergent findings in a form that could be tested in similar care environments. We develop statements relating (1) service quality constructs (extended SERVQUAL dimensions); (2) importance constructs (valence and salience); and (3) hospital context (neonatal unit levels). A summary of our study methodology is presented in Table 3.

5. Results and findings

5.1. Effects of gaps in care dimensions on maternity service satisfaction

An initial set of 65 topics or themes were identified from the free-text responses. These themes were further refined and finally consolidated into 27 care themes as discussed in Section 4.2. The Top-3 themes with the largest *quality gaps* (i.e. the highest prevalence) account for 32.30% of the whole analysed comments and include *Care Consistency* (11.60%); *Capacity Related Concerns* (11.20%); and *Insufficient Care Checks in Pre and Postnatal* (9.50%). The detailed results of mapping emergent care themes to SERVQUAL-related dimensions are provided as Web

Table 3
Summary of the computational text analytics methodological framework.

Discovery Phase	Measurement and Analysis Phase	Inferencing Phase
■ Sampling and Data Collection ■ Conceptualisation ■ Research Questions ■ What to measure	■ Synchronic analysis – Measuring prevalence of concepts – E.g. topical content, sentiment, readability, informativeness, emotions, tone – relationships and associations among concepts ■ Lexical framing – Align to existing theoretical constructs with predefined vocabulary	■ Inferencing – Predictive or causal inference – Inductive (or abductive) theory generation
■ Sampling and Data Collection – Survey responses of maternity service users – Response rate = 3204 out of 6357 (50%) ■ Conceptualisation – Free-text feedback comprise issues considered important for improving maternity care service ■ Research Questions – Care themes reported in free-text feedback and their quality gaps, affect and effect – How and hospital context affect the profiles of care themes – Relative importance of core themes & related dimensions considering their Valence and Salience ■ What to measure – 5 concepts – quality gaps, affect and effect, Valence and Salience	■ Synchronic analysis – Structural topic modelling to generate topics and their prevalence (quality gaps) – Estimating of degree of negative affect of themes using multiple sentiment libraries – Predictive modelling to estimate the effect of topics to overall satisfaction – Estimate the Valence and Salience of topics using prevalence, affect and effect ■ Lexical framing – Mapping themes to theoretical constructs in health service quality evaluation – Mapping themes to Policy domain Thematic areas	■ Inferencing – Predictive Inferencing: Care themes of highest importance in terms of their Salience and Valence that will have largest impact on overall satisfaction – Inductive theory generation Propositions linking gaps in care dimensions (as SERVQUAL constructs), their importance in terms of Valence and Salience attributes and possible effect of hospital environment

Table 4
Final topics labels and metrics (quality gap and effect of gap).

Care Theme	Care Dimension	Policy Thematic Area	Quality Gap	Effect of Gap
Care Consistency	Reliability	Effective Care and Support	0.116	0.069
Capacity Related Concerns	Tangibles	Use of Resources	0.112	0.165
Insufficient Care Checks in Pre and Postnatal	Process	Safe Care and Support	0.095	0.136
Staff Attitude	Empathy	Workforce	0.084	0.003
Appointment Management System	Process	Leadership Governance and Management	0.078	0.057
Ineffective communication	Communication	Person-centred Care and Support	0.078	0.074
Ineffective Post Care	Reliability	Effective Care and Support	0.052	0.103
Need for Increased Breastfeeding Support	Competency	Effective Care and Support	0.045	0.156
Access to Pain Relief	Pain Management	Person-centred Care and Support	0.040	0.106
Rushed Care	Reliability	Effective Care and Support	0.035	0.058
Positive Care Experience	–	Not Assigned	0.030	0.228
Partner Participation	Emotional/ Moral support	Effective Care and Support	0.030	0.060
Information Support and Individualised Options	Empathy	Person-centred Care and Support	0.029	0.128
Labour Postnatal Support and Delayed Appointments	Process	Effective Care and Support	0.023	0.103
Night-time Care Conditions	Tangibles	Effective Care and Support	0.023	0.063
Insufficient Amenities	Tangibles	Leadership Governance and Management	0.018	0.126
Deficit of Hospital Resources	Tangibles	Use of Resources	0.016	0.170
Quality of Food	Tangibles	Better Health and Wellbeing	0.013	0.154
Care Under Exceptional Circumstances	Empathy	Person-centred Care and Support	0.012	0.095
Management of Visiting Times	Process	Leadership Governance and Management	0.012	0.102
Discharge Issues	Process	Effective Care and Support	0.011	0.134
Integrated GP Care Services	Process (Coordination)	Effective Care and Support	0.011	0.193
Holistic Care Experience	Process	Effective Care and Support	0.011	0.170
Doctors Pre-visit Preparation	Process	Effective Care and Support	0.010	0.164
Insensitive Care Conditions	Empathy	Effective Care and Support	0.010	0.161
Labour Ward Access	Tangibles	Effective Care and Support	0.004	0.182
Detection and Treatment of Infections	Reliability	Workforce	0.004	0.159

Appendix B[6] while Table 4 provides a summary.

Regarding the *effect* of the themes and factors (from closed-form questions) on the overall care satisfaction, results from our Random Forest modelling described in Section 4, Step 1.c show that the factors had a relatively stronger predictive effect on the overall satisfaction than the themes extracted from textual feedback (Web Appendix C[7]). The Top-3 care themes with the strongest *effect* on the overall satisfaction are *Integrated GP Care Services* (0.193), *Labour Ward Access* (0.182), *Deficit of Hospital Resources* (0.170) and *Holistic Care Experience* (0.170). It must be noted that while the factors from the closed-form part of the survey had predictive power, *they had low explanatory power compared to these* themes. In addition, 6 of the 27 themes provide a refined understanding of the factors. The remaining 21 themes were new insights revealed from the textual feedback (Web Appendix D[8]).

Following the mappings described in Section 4.2, Step 2, the Top-3 SERVQUAL dimensions with the largest quality gaps or prevalence are *Process* (8 topics; 25.10%), *Reliability* (4 topics; 20.70%); and *Tangibles* (6 topics; 18.60%). The Top-3 care dimensions (SERVQUAL) with the strongest effects on the overall satisfaction are *Competency* (0.156), *Tangibles* (0.143), and *Process* (0.132).

In terms of the thematic areas, the Top-3 thematic areas associated with the largest *quality gaps* are *Effective Care and Support* (13 topics; 38.10%); *Person-centred Care and Support* (4 topics; 15.90%); and *Leadership Governance and Management* (3 topics; 10.80%). The Top-3 thematic areas with the strongest total *effect* on overall satisfaction are *Use of Resources* (0.168), *Better Health and Wellbeing* (0.154), and *Safe Care and Support* (0.136).

Regarding the largest quality gaps among different demographic groups, results from the three STM models built with women's *Age*, *Ethnicity,* and *Disability* as a Covariate are provided in Appendix E.[9] We determine the Top 3 care themes with the largest quality gaps for the different groups at the different hospital levels. The colours indicate themes that have a high effect on the overall care satisfaction at a particular hospital neonatal unit levels . For instance, for *older* women, *Insensitive Care Conditions* (*Empathy,* 0.057), *Deficit of Hospital Resources* (*Tangibles*, 0.051) and *Quality of Food* (*Tangibles*, 0.045) issues were found to have the largest quality gap; but *younger* women were more concerned about *Care Under Exceptional Circumstances* (*Empathy,* 0.051), *Detection and Treatment of Infections* (*Reliability,* 0.052), and *Insufficient Amenities* (*Tangibles*, 0.044). *White* women discussed the *Detection and Treatment of Infections* (*Reliability,* 0.054), *Labour Ward Access* (*Tangibles*, 0.057) and *Insensitive Care Conditions* (*Empathy,* 0.057) issues while *other* ethnic groups emphasised the need for improvements in Process-related issues such as *Appointment Management System (Process,* 0.047), *Discharge Issues* (*Process*, 0.060), and *Management of Visiting Times* (*Process,* 0.043). Women *without disabilities* identified wider care gaps in the *Detection and Treatment of Infections* (*Reliability,* 0.058), *Insensitive Care Conditions* (*Empathy*, 0.057), and *Deficit of Hospital Resources* (*Tangibles*, 0.054); but women *with disabilities* reported issues with *Information Support and Individualised Options* (*Empathy,* 0.058), *Night-time Care Conditions* (*Tangibles,* 0.058) and *Ineffective communication* (*Communication*, 0.044).

The Impact of Hospital Context on the Effect of Gaps in Care Dimensions.

Results from the three Random Forest prediction models built in Section 4.2, Step 1.c for three levels of hospitals' neonatal units are presented in Table 5. The care themes with the strongest *effect* of quality gaps on overall satisfaction for Neonatal Units Level 1 are *Deficit of Hospital Resources* (*Tangibles*, 0.251); *Quality of Food* (*Tangibles,* 0.238); *and Insensitive Care Conditions* (*Empathy,* 0.234). The themes for Level 2 are: *Need for Increased Breastfeeding Support* (*Competency,* 0.268); *Management of Visiting Times* (*Process,* 0.257); and *Information Support and Individualised Options* (*Empathy,* 0.251). The themes with the strongest effect for Level 3 are: *Doctors Pre-visit Preparation* (*Process,* 0.252); *Integrated GP Care Services* (*Process (Coordination),* 0.246); and *Insensitive Care Conditions* (*Empathy,* 0.231).

5.2. Prioritising care dimensions for improvement

We produced Table 6 and Fig. 2 based on the procedure described in Section 4.3 on the care gaps, and effect of care gaps reported in Sections 5.1. For each theme, the intensity of negative *affect* (0 most positive; 1 most negative) was determined. The Top 3 themes with the strongest negative affect are *Staff Attitude* (1.0), *Insensitive Care Conditions* (0.93), and *Rushed Care* (0.90). The related Top 3 care dimensions (SERVQUAL) with the strongest mean *negative* affect are *Empathy* (0.693), *Reliability* (0.540), and *Pain Management* (0.530). For the thematic areas, *Use of Resources* (0.670), *Workforce* (0.555), and *Effective Care and Support* (0.532) have the strongest negative affect. Regarding the *salience* of care issues, we identified *Capacity Related Concerns (Tangibles,* 1.0), *Insufficient Care Checks in Pre and Postnatal (Process,* 0.785), and *Care Consistency (Reliability,* 0.461) *to be the top 3 care themes and dimension.* The high *valence* themes identified were *Staff Attitude (Empathy,* 1.0), *Capacity Related Concerns (Tangibles,* 0.941), and *Insufficient Care Checks in Pre and Postnatal (Process*, 0.755).

To understand the impact of hospital context, we observed that for all hospitals, the most important for improvement care themes and related SERVQUAL dimensions are *Insufficient Care Checks in Pre and Postnatal (Process)* and *Capacity Related Concerns (Tangibles)*. However, for tertiary neonatal unit (level 3), *Capacity Related Concerns (Tangibles,* 1.0) comes to the fore by a significant margin. In third place for *local* neonatal unit, the issues with *Care Consistency (Reliability,* 0.833) are identified; for the *regional* neonatal unit – *Appointment Management System (Process,* 0.849) needs special attention; and for the *tertiary* maternity care hospitals the *Ineffective Communication (Communication,* 0.60) is a weak side in the patient experience. The composite of the valence and salience measures for each neonatal level are presented in Table 7 and web appendix F.[10]

5.3. Summary of findings

5.3.1. RQ1 – Effect of Quality Gaps in Care themes and dimensions on overall satisfaction

While the largest *quality gaps* were found in care themes related to Care Consistency (0.116), Care Capacity (0.112) and Insufficient Care Checks (0.095); the care themes that had the strongest *effect* on overall women's satisfaction were Integrated GP Care (0.193), Labour Ward Access (0.182), Deficit of Hospital Resources (0.170) and Holistic Care Experience (0.170). From a theoretical perspective, the care dimensions with the strongest *aggregate effect* on overall satisfaction were *Competency* (e.g. Breastfeeding Support, 0.156), *Tangibles* (e.g. Labour Ward Access, 0.182) and *Process* (e.g. Integrated GP Care, 0.193). *Thus, gaps in these three care dimensions are the strongest determinants of overall patient satisfaction in the context of maternity care (Proposition 1)*.

Furthermore, *how hospital context impacts the perceived gaps in different care dimensions, and their affect on overall satisfaction, was provided.* For instance, in the context of hospitals providing routine care to term infants (neonatal level 1: local), gaps in the *Tangible* and *Empathy* care dimensions were found the strongest determinants of overall satisfaction. In hospitals providing routine care to near-term infants and high dependency care with short-term ventilation (neonatal level 2: regional), gaps in *Competency, Process* and *Empathy* dimensions were the core determinants of overall satisfaction. Finally, in hospitals providing full spectrum care from full term to pre-term (neonatal level 3: tertiary),

[6] Web Appendix B
[7] Web Appendix C
[8] Web Appendix D
[9] Web Appendix E
[10] Web Appendix F

Table 5
The Top-10 care themes with the strongest effects on the overall satisfaction across hospital context.

Level 1, Local care	Effect of Gap	Policy Thematic Area	Level 2, Regional care	Effect of Gap	Policy Thematic Area	Level 3, Tertiary care	Effect of Gap	Policy Thematic Area
Deficit of Hospital Resources (Tangibles)	0.251	Use of Resources	Need for Increased Breastfeeding Support (Competency)	0.268	Effective Care and Support	Doctors Pre-visit Preparation (Process)	0.252	Effective Care and Support
Quality of Food (Tangibles)	0.238	Better Health and Wellbeing	Management of Visiting Times (Process)	0.257	Leadership Governance and Management	Integrated GP Care Services (Process (Coordination)	0.246	Effective Care and Support
Insensitive Care Conditions (Empathy)	0.234	Effective Care and Support	Information Support and Individualised Options (Empathy)	0.251	Person-centred Care and Support	Insensitive Care Conditions (Empathy)	0.231	Effective Care and Support
Holistic Care Experience (Process)	0.212	Effective Care and Support	Holistic Care Experience (Process)	0.246	Effective Care and Support	Capacity Related Concerns (Tangibles)	0.23	Use of Resources
Integrated GP Care Services (Process (Coordination)	0.191	Effective Care and Support	Labour Ward Access (Tangibles)	0.235	Effective Care and Support	Rushed Care (Reliability)	0.228	Effective Care and Support
Labour Ward Access (Tangibles)	0.177	Effective Care and Support	Ineffective Post Care (Reliability)	0.229	Effective Care and Support	Management of Visiting Times (Process)	0.226	Leadership Governance and Management
Management of Visiting Times (Process)	0.177	Leadership Governance and Management	Insensitive Care Conditions (Empathy)	0.223	Effective Care and Support	Labour Ward Access (Tangibles)	0.205	Effective Care and Support
Insufficient Amenities (Tangibles)	0.173	Leadership Governance and Management	Quality of Food (Tangibles)	0.213	Better Health and Wellbeing	Holistic Care Experience (Process)	0.199	Effective Care and Support
Doctors Pre-visit Preparation (Process)	0.172	Effective Care and Support	Detection and Treatment of Infections (Reliability)	0.211	Workforce	Discharge Issues (Process)	0.199	Effective Care and Support
Discharge Issues (Process)	0.146	Effective Care and Support	Insufficient Amenities (Tangibles)	0.203	Leadership Governance and Management	Insufficient Care Checks in Pre and Postnatal (Process)	0.18	Safe Care and Support

gaps in *Process* and *Empathy* dimensions had the greatest *effect* on satisfaction. *We therefore hypothesise that "Hospital context does not impact the effect of perceived gaps in the empathy care dimension on overall patient satisfaction. However, hospital context may impact the effect of gaps in other care dimensions on the overall patient experience" (Proposition 2).*

5.3.2. RQ2 – Prioritising Gaps in Care themes and dimensions for improvement

We found that care themes related to Staff Attitude (1.0), Insensitive Care Conditions (0.93) and Rushed Care (0.9) were associated with high *negative affect*. When considering care dimensions, *Empathy, Reliability,* and *Pain Management* issues were associated with the highest negative affect or strongest emotions.

The care dimensions with the highest *valence* were *Empathy* (Staff Attitude, 1.0), *Tangibles* (Capacity Related Concerns, 0.94) and *Process* (Insufficient Checks in Pre and Postnatal, 0.76). Similarly, care dimensions with high *salience* include *Tangibles* (Capacity Related Concerns, 1.0), *Process* (Insufficient Checks in Pre and Postnatal, 0.79) and *Reliability* (Care Process Consistency, 0.46). When combined, gaps in the care dimensions of *Tangibles* (1.0), *Process* (0.79), and *Reliability* (0.59) are associated have high importance for improvement in maternity care. *Thus, we hypothesise that reducing the perceived gaps in these three care dimensions will have the largest impact on both overall satisfaction and patient negative emotions (Proposition 3).*

From Table 7, *we infer that hospital context does not affect the importance of the gaps in the two care dimensions – Tangibles and Process (Proposition 4)*. We note that although Reliability and Communication appear as dimensions of high importance for all three levels, they do not appear *consistently* in the top five of all three hospital contexts. Therefore, we encourage further investigation in establishing the effect of hospital contexts on Reliability and Communication. *Consequently, beyond Tangibles and Process care dimensions, hospital context may impact the relative importance of the gaps in other care dimensions.*

6. Discussion

Textual and other forms of data are increasingly used as complementary sources of evidence to support formal decision-making and policy formulation in addition to traditional statistical data. In the context of this study, the goal is to harness free-text feedback, collected as part of a national survey, to provide additional and deeper insights into the information obtained from the closed-form questions for improving the maternity care experience. While the study is similar in objective to those reported by [2,96], it differs significantly in its ambition regarding the quality, timeliness of evidence, scalability of method regarding the volume of the qualitative dataset, and the preservation of the depth of analysis afforded in traditional qualitative analysis. Most existing studies that have adopted domain-agnostic computational approaches such as text mining, topic modelling, or big data analytics techniques such as [6] though offer high practical utility based on their high predictive accuracy, they have relatively weak explanatory capabilities, thus limiting their use in formal decision-making such as our study context. However, these techniques have the potential to yield new constructs and opportunities for theorising [95] and emerging efforts like [12] show how these techniques could be extended to support theory building. Our approach, which builds on Computational Grounded Theory [13] and the guidelines in [7,14] affords the discovery of theoretically grounded themes and the development of "substantive theories" (as propositions) with the potential to inform decisions on maternity care service improvements.

We argue that the study makes significant contributions from theoretical, methodological, and healthcare policy perspectives as discussed below.

6.1. Theoretical implications

The study makes the following key contributions from the theoretical perspective. First, the study extends the lexicon of SERVQUAL to explicitly support the prioritisation of quality gaps in service dimensions

Table 6
Valence and salience for latent themes.

Themes	Effect of the Gap	Affect	Valence	Salience	Valence & Salience
Capacity Related Concerns (Tangibles)	0.165	0.65	0.941	1	1
Insufficient Care Checks in Pre and Postnatal (Process)	0.136	0.47	0.755	0.785	0.794
Care Consistency (Reliability)	0.069	0.43	0.748	0.461	0.587
Need for Increased Breastfeeding Support (Competency)	0.156	0.17	0.328	0.448	0.375
Ineffective communication (Communication)	0.074	0.36	0.611	0.393	0.491
Ineffective Post Care (Reliability)	0.103	0.72	0.689	0.364	0.5
Appointment Management System (Process)	0.057	0.36	0.611	0.308	0.434
Access to Pain Relief (Pain management)	0.106	0.53	0.522	0.281	0.38
Information Support and Individualised Options (Empathy)	0.128	0.33	0.344	0.248	0.277
Deficit of Hospital Resources (Tangibles)	0.17	0.69	0.416	0.19	0.276
Integrated GP Care Services (Process)	0.193	0.85	0.412	0.151	0.25
Quality of Food (Tangibles)	0.154	0.27	0.213	0.146	0.151
Insufficient Amenities (Tangibles)	0.126	0.73	0.442	0.145	0.259
Holistic Care Experience (Process)	0.17	0.76	0.396	0.142	0.237
Labour Postnatal Support and Delayed Appointments (Process)	0.103	0.25	0.262	0.132	0.168
Doctors Pre-visit Preparation (Process)	0.164	0.46	0.288	0.127	0.178
Insensitive Care Conditions (Empathy)	0.161	0.93	0.412	0.125	0.234
Discharge Issues (Process)	0.134	0.23	0.178	0.096	0.105
Labour Ward Access (Tangibles)	0.182	0	0	0.081	0
Rushed Care (Reliability)	0.058	0.9	0.606	0.068	0.267
Detection and Treatment of Infections (Reliability)	0.159	0.11	0.067	0.066	0.029
Partner Participation (Emotional/Moral support)	0.06	0.47	0.426	0.042	0.186
Staff Attitude (Empathy)	0.003	1	1	0.04	0.306
Management of Visiting Times (Process)	0.102	0.49	0.314	0.034	0.133
Care Under Exceptional Circumstances (Empathy)	0.095	0.51	0.323	0.017	0.126
Night-time Care Conditions (Tangibles)	0.063	0.75	0.485	0	0.179

from textual feedback based on the decision concepts of valence and salience. While the concept of valence is relatively well theorised, the antecedents of issue salience are under-theorised [28]. We have provided an initial theorisation of the antecedents of issue salience (Section 2.1) and operationalisation of both salience and valence in the context of maternity care (Section 4.1). This has enabled us to determine the effect of gaps in maternity care themes and dimensions on overall satisfaction, how these gaps should be prioritised and if hospital context impacts the effects and importance of quality gaps in care dimensions. Our findings led to the following propositions:

P1. *Quality Gaps in Competency* (e.g. Breastfeeding support), *Tangibles* (e.g. Labour ward access) and *Process* (e.g. Integrated GP care) *care dimensions are strong determinants of overall service satisfaction in the context of maternity care*

P2. *Hospital context (neonatal unit level) does not impact the effect of perceived gaps in the Empathy care dimension on overall patient satisfaction. However, hospital context may impact the effect of gaps in other care dimensions on the overall service satisfaction.*

P3. *Quality gaps in Tangibles*, *Process* and *Reliability care dimensions have high importance (high salience and valence) among maternity services users*

P4. *Hospital context (neonatal unit level) does not affect the importance of the gaps in the two care dimensions – Tangibles and Process. However, hospital context may impact the relative importance of the gaps in other care dimensions.*

The above findings have support in extant literature on maternity service experience. For instance, the Tangibles dimension turned out to have the highest gap score for Pregnant Woman Satisfaction and Quality of Maternal and Child Health Care Services [97–100]. Similarly, in [101], nursing (Tangibles), hospital premises and employees (Tangibles), and room and housekeeping courtesy, were noted as having a significant impact on overall perceptions of service quality. In another study, the highest quality gap was found for the Reliability dimension followed by Tangibles in maternity care services [102]. Finally, a study on maternity patients' perception of care found that the most important service quality dimensions identified by respondents were Reliability; Assurance; and Tangibles [103].

Secondly, through our lexical mapping to the SERVQUAL dimensions [34], we provided potentially new scales for measuring the well-known dimensions of the framework and also identified additional dimensions or constructs that were critical in our study domain including Process, Communication, and Emotional support.

Thirdly, our work contributes significantly to the literature on techniques for establishing key determinants of maternity care service satisfaction. In this vein, some of our results have been validated by other studies conducted using more traditional qualitative and quantitative approaches using the same national maternity experience dataset [104].

6.2. Methodological implications

First, our study contributes to the emerging body of literature on computational grounded theory and related methods by offering a detailed implementation of the methodology in the context of a national-scale research project. We have shown how the computational grounded theory (CGT) approach could be employed in a real-life case study thus contributing to literature in this area. The use of CGT here affords ongoing expert and researcher interrogation and analysis of the emergent patterns produced from the textual data for sensemaking and mapping to higher-level thematic structures that are more meaningful for the end-user decision-, and policy-makers, or knowledge users.

We are unaware of any study that has attempted to provide such detailed CGT implementation. We also believe that our work makes important methodological contributions to emerging policy analytics literature. This is against the background that policymaking is a type of decision process with specific characteristics that require dedicated analytical methodologies [105]. In our case, we have developed a computationally rigorous yet practical approach to support policy monitoring and change in the context of maternity care services based on free-text feedback. The barrier to the use of free-text data as a source of admissible evidence for formal decision-, or policy-making is largely associated with the paucity

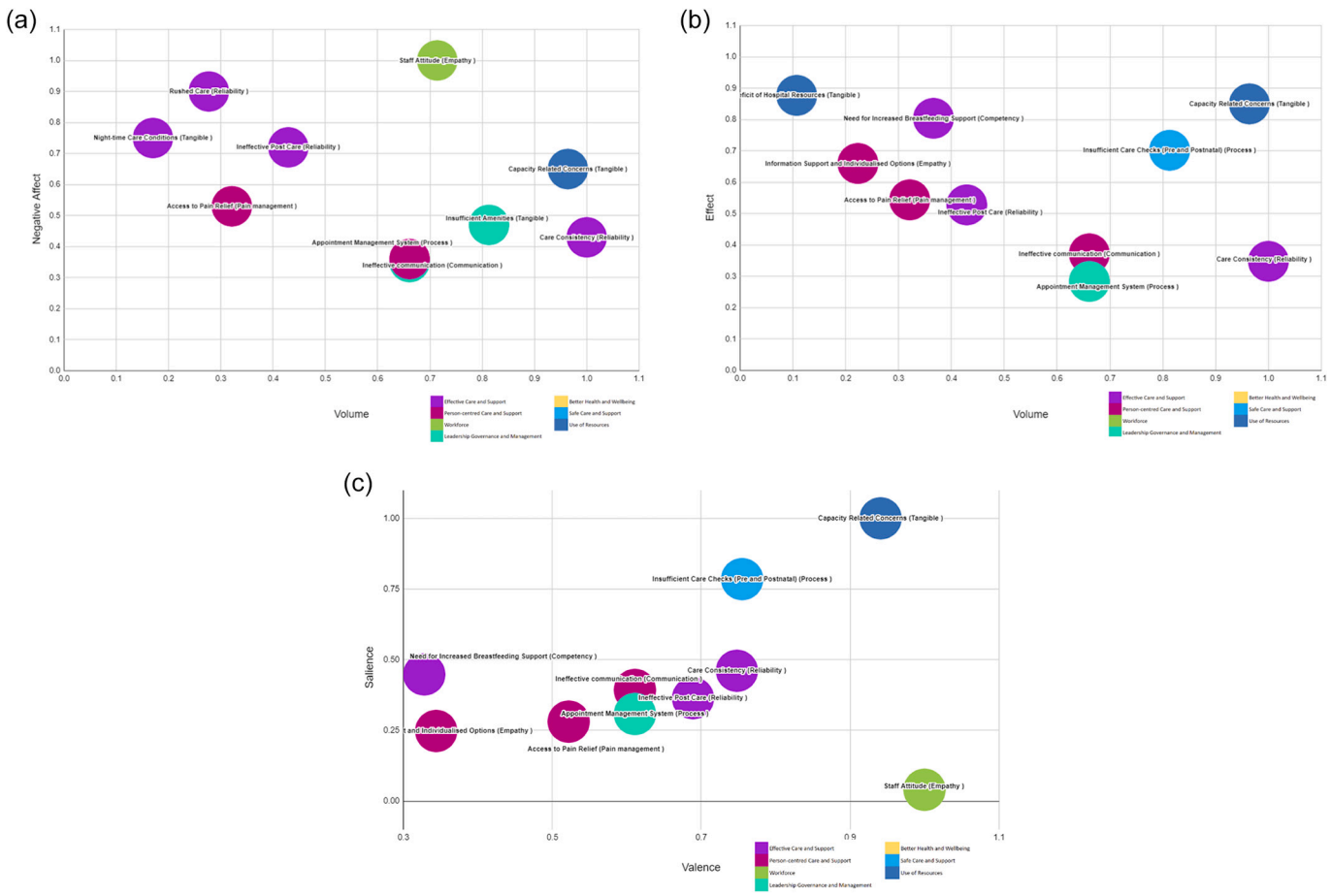

Fig. 2. Valence and salience for latent themes.

Table 7
Valence & Salience (V&S) of latent themes across hospital contexts.

Level 1, Local care	V&S	Level 2, Regional care	V&S	Level 3, Tertiary care	V&S
Insufficient Care Checks in Pre and Postnatal (Process)	1.000	Insufficient Care Checks in Pre and Postnatal (Process)	1.000	Capacity Related Concerns (Tangibles)	1.000
Capacity Related Concerns (Tangibles)	0.840	Capacity Related Concerns (Tangibles)	0.937	Insufficient Care Checks in Pre and Postnatal (Process)	0.763
Care Consistency (Reliability)	0.833	Appointment Management System (Process)	0.849	Ineffective communication (Communication)	0.600
Ineffective communication (Communication)	0.744	Ineffective Post Care (Reliability)	0.756	Appointment Management System (Process)	0.571
Appointment Management System (Process)	0.741	Staff Attitude (Empathy)	0.724	Rushed Care (Reliability)	0.529
Ineffective Post Care (Reliability)	0.725	Ineffective communication (Communication)	0.697	Access to Pain Relief (Pain Management)	0.429
Rushed Care (Reliability)	0.534	Care Consistency (Reliability)	0.607	Ineffective Post Care (Reliability)	0.384
Partner Participation (Emotional/Moral support)	0.525	Insufficient Amenities (Tangibles)	0.469	Information Support and Individualised Options (Empathy)	0.370
Staff Attitude (Empathy)	0.495	Partner Participation (Emotional/Moral support)	0.401	Staff Attitude (Empathy)	0.368
Deficit of Hospital Resources (Tangibles)	0.380	Access to Pain Relief (Pain Management)	0.398	Care Consistency (Reliability)	0.322

of *scalable* techniques for rigorous analysis of large free-text datasets [3,4].

6.3. Policy implications

From a policy perspective, the findings highlight the key areas for improvement, thus informing the Theory of Change for the National Maternity Care Programme. *The resulting ToC is that at a national system level, improvement actions in the areas of tangibles, process, and reliability care dimensions (established to have the greatest importance) will most generally have the strongest impact on overall service satisfaction.* However, when considering specific maternity care environments (i.e. with different levels of neonatal care), tangibles and process remain as priority care areas for action but would need to be complemented with actions in other specific care dimensions as in Table 7.

Furthermore, of the eight policy areas in the National Maternity Standards, Effective care and support is the most dominant policy area. The care consistency and ineffective post-care issues as a dimension of effective care and support arise, highlighting the need for standards throughout the whole maternity care experience from prenatal to postpartum. The issues in the Person-centred Care and Support policy area, related to ineffective communication and the need for staff to improve their active listening skills and communication efficacy during the care experience, are identified as critical for improvement. The

policy area Leadership, Governance, and Management strongly highlights the importance of issues related to appointment delays, management of visiting times, and rushed care all of which are hallmarks of an overburdened health system. The Workforce policy area highly emphasises the most negative issues regarding further elaboration on staff attitude. The Use of Resource policy area emphasises the need to pay special attention to concerns related to capacity and deficit of hospital resources, which has a significant effect on predicting the overall maternity experience rating. The Use of Information policy area may not have appeared relevant to the women as it is predominantly an internal dimension focused on internal planning, monitoring, and managing care. Consistent, standardised care appears lacking in maternity services; standard adherence is imperative if there is to be care consistency in the maternity service care system and throughout the various stages of the labour process [106,107].

The need for increased breastfeeding support surfaces as a maternity care, domain-specific issue that is a critical area requiring attention. Interestingly, Ireland has one of the world's lowest breastfeeding rates [108] illustrating the alignment between women's support needs and the resultant macro trend toward breastfeeding prevalent in the country. The second maternity care domain-specific critical area is concerned with pre and postnatal care checks and especially mental health checks for mothers; the identified need within the women's care experience responses is again a signal of a larger identified issue within the country's maternity services as a recent study acknowledges that the "current model of 6-week postpartum care in Ireland is insufficient to detect and provide adequate support for women's mental health needs" [109]. Similarly, the accompanying HIQA report on the National Standards Survey results [110] identifies the need for more information about mental health changes following pregnancy, interestingly, this deficit of information around mental health is lessened for those who saw a midwife as their initial point of contact on pregnancy than those who saw their GP. This highlights the importance of early-stage contact with specialised, trained professionals within the maternity services system. Furthermore, the report's key finding around mental health support deficiencies identified that several women felt they had insufficient time during the 6-week postpartum check-up to discuss their physical and mental health needs.

6.4. Limitations and future research

Our work has two important limitations that we wish to point out. The first is related to the consideration of only comments concerned with "improvements" in the National Maternity Experience Survey dataset utilised as the basis for determining required improvements in maternity services. It is quite possible that comments about the "good experiences" of women who have received maternity care could also be used in identifying aspects of maternity services that are very important from the service users' perspective, and thus could be considered for further enhancement. For instance, if the marginal utility gained from a positive experience in a particular aspect of care far outweighs the marginal utility loss or deficit from a particularly negative experience, it may be more expedient from a practical standpoint to further strengthen or at least maintain the positive experience. Considering comments on good experiences, in addition to comments about improvements, will also increase the explanatory power (r-squared) of the Random Forest model used for estimating the influence of emergent themes on the service satisfaction rating.

The second limitation of our study is related to the assumption underpinning the issue valence and salience. These assumptions, though theoretically guided, need explicit validation in the field considering that the process and different aspects of policymaking are typically carried out in a "bounded or limited rationality" and political context. For instance, the prioritisation of policy initiatives may be determined by the available resources, political preference or agenda, or experience of what worked in the past [111]. Thus, what appears to be the most important from a purely rational consideration may not be considered as such from the policy-, or decision-makers perspective.

This field of enquiry would benefit from future research that tests the developed propositions in similar care contexts (i.e. maternity care involving similar demographics and hospital contexts). In addition, future studies in this area may consider additional information from service users (e.g., comments on good experience) when determining priority areas of improvement and may also examine how purely rational decision processes can be enhanced with more pragmatic considerations of decision processes in policymaking contexts.

7. Conclusions

This study integrates computational text and predictive modelling as part of a Computational Grounded Theory method to identify important care issues for improving maternity services from free-text feedback. The concrete and actionable insights from our analysis demonstrate the efficacy of our methodological approach. While some of our findings have been validated based on recently published reports and articles, our future work includes understanding other factors that could affect the prioritisation of emergent themes beyond those considered in the present study. Possible challenges for policymakers in using these results also need to be better understood. Although this study is based on national-level data from Ireland, the care needs of women seeking access to maternity services are broadly similar across the world, thus the factors that can improve services in an Irish care context are likely to also enhance maternity care performance in other geographical contexts. Specifically, for policymakers, this study highlights the aspects of maternity service provision that require improvement based on the perceived care experiences of the women accessing maternity care. Additionally, it provides a service satisfaction prioritisation system which enables policymakers to determine the aspects of care that require immediate attention over those of a slightly lesser imperative. Furthermore, within the UN Sustainable Development Goals (SDGs) framework, our work provides a concrete decision tool to support the attainment of key targets related to improving maternal and neonatal care under SDG 3 which is concerned with good health and well-being in general.

Authors' contributions

1. Prof Adegboyega Ojo - led the conception, research design, and data analysis; wrote the introduction, part of methodology, part of the results; wrote discussion and conclusion sections; and prepared the figures.
2. Dr. Nina Rizun - conducted the data analysis, wrote part of the literature review, wrote the methodology, part of the results, conducted expert coding, and prepared all the tables and appendices materials.
3. Dr. Grace Walsh – developed the literature review, conducted expert coding, and contributed to the interpretation of the data and the development of the impact section.
4. Dr. Mona Isazad Mashinchi – contributed to the literature background, interpretation of the data, inferencing
5. Maria Venosa – data coding, topic labelling
6. Manohar Narayana Rao – data curation and management

CRediT authorship contribution statement

Adegboyega Ojo: Conceptualization, Formal analysis, Funding acquisition, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Nina Rizun:** Formal analysis, Methodology, Validation, Writing – original draft, Writing – review & editing. **Grace Walsh:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing. **Mona Isazad Mashinchi:** Data curation, Investigation, Project administration, Writing – review & editing. **Maria Venosa:** Data curation, Investigation. **Manohar Narayana Rao:** Data

curation, Investigation, Software.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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