

Fear inoculation through medical exposure: A domain-specific analysis of medical fears in patients living with diabetes mellitus

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ABSTRACT

Medical fears are common and can interfere with medical care. While repeated exposure to fear-relevant stimuli can reduce fear, evidence from real-world settings remains limited. Consequently, we examined whether exposure to medical procedures in a natural setting is associated with lower levels of domain-specific medical fear in individuals with diabetes mellitus (DM). A total of 401 participants with type 1 or type 2 DM or insulin resistance completed the Medical Fear Survey, which assesses five domains: injections and blood draws, sharp objects, blood, examinations and symptoms, and mutilation. We analyzed associations using Bayesian multiple regression with model averaging, including injection frequency, examination frequency, DM type, sex, age, and time since diagnosis as predictors. DM type was found to be the most consistent predictor, with type 1 and type 2 DM being associated with lower fear in domains related to injections, blood, and sharp objects, compared to insulin resistance. Injection frequency showed a domain-specific association, predicting lower fear only for injections and blood draws. We did not find meaningful associations for examination- or mutilation-related fears. Sex differences were present, with women reporting higher fear, but these did not modify the associations between medical experience and fear. Our findings suggest that the associations between medical experience and fear are specific to the domain in question, which supports the idea that fear reduction is stimulus-bound. More extensive and invasive long-term medical exposure appears to be linked to broader reductions in related fears, whereas frequent exposure to specific procedures shows more localized associations.

1. Introduction

Blood-Injection-Injury (BII) phobia is one of the most common specific phobias, with a global lifetime prevalence of 3% (Wardenaar et al., 2017). However, prevalence rates vary from 0.8% to 9.1%, and it is estimated that approximately one in five people will experience BII phobia at least once in their lifetime (Berg Johnsen et al., 2024). Studies often reveal sex differences, with the condition potentially affecting twice as many women as men (Wani et al., 2014). BII is characterized by an irrational fear of blood, injury, injections or other medical procedures. While these numbers may not seem high, they only cover the phobic level of fear, which is accompanied by syncope or presyncope (i. e., loss of consciousness or near-fainting) in the vast majority of cases (Öst et al., 1984). However, clinically significant fears related to medical procedures extend well beyond the narrow diagnostic category of blood-injection-injury (BII) phobia. In this broader sense, medical fears

encompass related yet distinct fears of injections, blood, injury, medical examinations and bodily harm. These fears have overlapping triggers, physiological responses and avoidance tendencies and are often considered to lie on a spectrum ranging from mild situational fear to phobic-level avoidance (Kleinknecht et al., 1996; Olatunji et al., 2012), with up to 50% experiencing mild to intense fear of medical procedures such as examinations, dentistry, and injections (Kılıç et al., 2021; McLenon & Rogers, 2019; Zsido et al., 2023). Throughout this paper, we therefore treat medical fears as a broader construct that subsumes, but is not limited to, traditional BII fear. Besides the obvious drawbacks of elevated anxiety levels and discomfort, as well as the development of comorbid mental health issues, higher rates of medical fear has broader health and societal effects. High levels of medical fear are correlated with a higher likelihood of avoiding treatment (Birkás et al., 2023), which affects overall health, quality of life, and patient management.

Notably, fears related to needles and injections are particularly

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prevalent among people living with diabetes mellitus. Previous research indicates that fear of injections is common among people with diabetes, in certain populations estimates can reach as high as 80% (Duncanson et al., 2021; McLaren & Rogers, 2019). This can significantly interfere with adherence to treatment and management of the disease (Fu et al., 2009). For instance, a significant proportion of patients report fear or avoidance in relation to insulin injections, which has been associated with poorer glycemic control and adverse health outcomes. Elevated fear of needles has also been documented in specific diabetic subpopulations, such as pregnant women with diabetes, among whom it is especially prevalent (Feitosa et al., 2013). These findings suggest that people with diabetes are frequently exposed to medical procedures involving needles and represent a clinically relevant group in which variation in fear levels can be meaningfully studied.

Medical fears are a heterogeneous concept encompassing a variety of distinct yet interconnected fears related to medical procedures and bodily harm (Kleinknecht et al., 1996; Olatunji et al., 2012). These domains are useful for identifying the specific fears of individuals, as medical fears can include a variety of situations, places, procedures, stimuli, and professions. In contrast, the domains break these fears down into five categories: (1) injections and blood draws (fears related to needles and venipuncture); (2) sharp objects (fears related to instruments that may cause injury); (3) blood (fears related to the visual presence of, or thoughts about, blood); (4) examinations and physical symptoms (anxiety about undergoing medical evaluations or experiencing signs of illness); and (5) mutilations (fears related to physical injury, disfigurement, or surgical harm). This is reflected in the factor structure of the Medical Fear Survey, a questionnaire developed nearly three decades ago that is widely used to assess medical fears in patients and community samples (Kleinknecht et al., 1996; Olatunji et al., 2012). Crucially, the five-domain structure of the Medical Fear Survey (MFS) reflects the heterogeneous nature of medical fears. It distinguishes between fear responses to specific stimuli (e.g. needles, blood, sharp objects) and more contextual or anticipatory aspects of medical care (e.g. examinations and symptoms). This domain-specific approach is theoretically relevant for testing fear inoculation accounts, since it is expected that repeated exposure will reduce fear most strongly for stimuli that closely match experienced medical procedures rather than producing uniform reductions across all fear domains (Coelho et al., 2023; Olatunji et al., 2012). Clinically, it can inform more targeted interventions by identifying the specific medical stimuli or contexts that provoke avoidance, distress or vasovagal symptoms. Rather than treating medical fears as a unitary construct, a domain-specific approach acknowledges the nuanced and idiosyncratic nature of medical fear experiences.

The potential fear-mitigating effect of having previous experience of the object or event that causes fear has been widely documented. This phenomenon is often referred to as fear inoculation (Fyer, 1998). Individuals who have had frequent or early contact with potentially threatening stimuli, such as snakes (Coelho et al., 2021), dogs (Doogan & Thomas, 1992), or dental procedures (Zsido et al., 2025), tend to report lower levels of fear than those with little or no prior exposure even following an aversive encounter (e.g. a dog bite or snakebite). This protective effect may stem from a greater sense of control over the stimulus or habituation, whereby repeated, non-threatening exposure reduces the novelty and emotional significance of the stimulus (Coelho & Purkis, 2009). These mechanisms form the basis of exposure-based therapies, which are widely used to treat phobias (Böhnlein et al., 2020; Botella et al., 2017). Understanding how and under what conditions fear inoculation occurs is important for theory and clinical practice. However, this phenomenon is difficult to study directly as it often requires longitudinal designs or the recruitment of specific populations. Although the concept of fear inoculation implies a causal mechanism whereby repeated exposure leads to reduced fear, the present study employs a cross-sectional design. Therefore, the observed associations should not be interpreted as evidence of causality; alternative

explanations, such as individuals avoiding certain medical procedures due to higher levels of medical fear, remain plausible.

In the present study, we address this challenge by focusing on individuals with various diabetes-related metabolic conditions, such as type 1 and type 2 diabetes mellitus (DM) and insulin resistance (IR). The insulin resistance (IR) group consisted of individuals who reported having been diagnosed with insulin resistance or related metabolic conditions, but not with diabetes mellitus. This group can be clinically characterized as being at an earlier or less severe stage of metabolic dysregulation, typically involving fewer invasive medical procedures and less intensive disease management than individuals with type 1 or type 2 DM (Ogawa et al., 2022; Petersmann et al., 2019). However, there are also notable differences in terms of experience with injections in the different types of diabetes mellitus (DM) (Haller et al., 2005; Ogawa et al., 2022; Petersmann et al., 2019). Individuals with Type 1 DM must frequently check their blood sugar levels and must take insulin through injections or an insulin pump to survive. The treatment for Type 2 DM includes diet, exercise, and weight management, the use of oral medications, and sometimes insulin injections. Insulin resistance treatment primarily focuses on lifestyle modifications and may include medication. Their frequent exposure to potentially fear-inducing medical stimuli provides an opportunity to investigate whether repeated, real-world contact contributes to reduced medical fears.

The overarching goal of the present study was to test whether frequent exposure to medical procedures would reduce fears associated with medical treatment by acting as a form of inoculation. To this end, we recruited patients with various types of DM, since preventing the disease from worsening necessitates constant medical attention, including regular examinations. Treatment often involves self-administered injections. We expected that attending more frequent examinations and receiving more frequent injections would reduce fear in the corresponding domains. Specifically, we hypothesized that experiencing a particular procedure would reduce fear of that procedure; for instance, frequent examinations would reduce fear of examinations, and frequently receiving injections would reduce fear of injections. We also hypothesized that these effects would generalize to some extent, reducing fears related to blood and sharp objects, albeit less pronouncedly. We did not expect to find any such effects regarding mutilation.

2. Methods

2.1. Participants

We calculated the minimum required sample size for a linear multiple regression ($r^2 = 0.06$, $1 - \beta > 0.8$, $\alpha = 0.05$, N of predictors = 6) using G*Power 3 software (Faul et al., 2007). The analysis indicated a minimum required sample size of 234. However, beyond the minimum sample size suggested by the a priori power analysis, we aimed to have at least 100 observations per condition (i.e. at least 100 participants per subgroup in the grouping variables). We selected this target in order to enhance the stability and accuracy of the parameter estimates, and to guarantee that Bayesian model comparisons would be based on data that was sufficiently informative, rather than representing a formal sample size requirement (Kruschke, 2015; Vasishth et al., 2023). A total of 401 participants (339 women) aged between 18 and 78 years (mean = 40.21, standard deviation = 14.22) were recruited. Table 1 shows the central tendencies of the questionnaires and provides further details about the sample.

All participants were recruited via the internet through an online survey using Google Forms. To obtain a diverse sample, invitations to participate in the study were posted on various social media forums and mailing lists focused on living with and managing DM. Participation was voluntary and anonymous, and respondents could withdraw at any time without facing any consequences. As the platform only records submitted questionnaires, it was not possible to determine how many

Table 1

Detailed descriptive statistics of the sample, including demographic variables and questionnaires used in the study.

	Category	Count	Percentage	
Diabetes type	Type 1	113	28.2%	
	Type 2	111	27.7%	
	Insulin resistant	177	44.1%	
Receiving injections frequently	Never	263	65.6%	
	Monthly	2	0.5%	
	Daily	12	3.0%	
	Several times a day	104	25.9%	
	Missing	20	5.0%	
Frequency of examinations	Weekly	14	3.5%	
	Every three months	128	31.9%	
	Every six months	120	29.9%	
	Annually	105	26.2%	
	Never	34	8.5	
Time since receiving diagnosis	Mean	SD	Min	Max
	9.611 years	8.959	1	46
MFS IBD	1.893	2.743	0	12
MFS SO	1.945	2.634	0	15
MFS ES	8.187	3.765	0	18
MFS BL	2.362	3.276	0	15
MFS MU	8.646	3.916	0	15

individuals accessed the survey but did not complete it. Consequently, it was not possible to calculate a response rate. Data collection ceased once the target sample size had been reached. None of the submitted questionnaires were excluded, as none showed evidence of invalid, duplicate or otherwise suspicious responses. All respondents gave written informed consent to participate in the study. The research was approved by the (*name of committee and approval nr. blinded for peer review*), and was conducted in accordance with the World Medical Association's Code of Ethics (Declaration of Helsinki).

2.2. Questionnaires

We obtained sociodemographic data, including age, sex, and type of DM (Type 1, Type 2, or insulin resistance). Participants self-reported their diagnosis by selecting from predefined categories (type 1 DM, type 2 DM or insulin resistance). Those who selected 'insulin resistance' were not reported to have diabetes mellitus and were treated as a distinct clinical group, reflecting an earlier stage of metabolic impairment or a non-diabetic condition. Participants were then asked to state the year they received their diagnosis, how often they attend examinations (never, weekly, monthly, every three months, every six months, yearly), and how often they receive injections (never, several times a month, daily, several times a day). These frequencies were determined based on consultation with a DM specialist. We also created a new variable recording how long ago they received the diagnosis (by subtracting the year of diagnosis from the current year).

We assessed the different aspects of medical fears using the abbreviated version of the Medical Fear Survey (MFS) (Olatunji et al., 2012). This 25-item questionnaire assesses fears relating to five areas: injections and blood draws (IBD), sharp objects (SO), blood (BL), mutilation (MU), and examinations and symptoms (ES). Participants rated each item on a 5-point Likert scale ranging from 0 (no fear) to 4 (extreme fear). Higher scores indicate higher levels of fear on the given subscale. In this study, McDonald's omega coefficients were 0.84 (IBD), 0.80 (SO), 0.89 (BL), 0.81 (MU), and 0.80 (ES).

2.3. Analytic approach

All analyses were conducted in JASP version 0.19.3 (JASP Team, 2020) using the default prior settings for Bayesian regression. We analyzed the data using Bayesian multiple regression with model averaging. Each of the five subscales of the Medical Fear Survey (MFS)—Injection and Blood Draws, Sharp Objects, Examinations and Symptoms, Blood, and Mutilation—was analyzed using a separate regression model. For each outcome, we considered a common set of predictors reflecting medical experience and individual characteristics, including injection frequency, diabetes type (Type 1, Type 2 or insulin resistance), sex, age, examination frequency and time since diagnosis.

Rather than relying on a single 'best' model, we used Bayesian model averaging. This approach evaluates all possible combinations of predictors, weighing their contribution according to their explanatory power. As a result, uncertainty about model selection is explicitly taken into account. For each predictor, we report its posterior inclusion probability and the associated Bayes factor for inclusion. These quantify how strongly the data supports including the predictor in the model compared to excluding it. Predictors with Bayes factors clearly favoring inclusion were interpreted as showing evidence of an association with the outcome, whereas predictors with Bayes factors favoring exclusion were interpreted as showing evidence against a meaningful association. The focus of the interpretation is on which predictors matter and in which direction. We report posterior estimates and credible intervals in a table to indicate the direction and range of plausible effects.

3. Results

3.1. Fear of injections and blood draws

Fear related to injections and blood tests was most clearly associated with medical experience and diabetes-related factors. Detailed statistical results are shown in Table 2. Model-averaged results indicated that diabetes type, injection frequency and age should be included as predictors of fear in this domain. More frequent injections were associated with lower fear scores, which is consistent with the idea that repeated exposure can reduce anxiety related to injections. Diabetes type also emerged as an important predictor, with the overall pattern indicating lower fear among individuals with type 1 or type 2 diabetes compared to those with insulin resistance. Fig. 1 presents the descriptive statistics for these comparisons. Additionally, there was some evidence of a small negative association with age, indicating slightly lower fear at higher ages. In contrast, sex, examination frequency and time since diagnosis showed little evidence of contributing to fear of injections and blood tests once other variables were taken into account.

3.2. Fear of sharp objects

The strongest and clearest predictor of fear of sharp objects was sex. Detailed statistical results are shown in Table 2. The results showed strong evidence that fear levels differed between males and females, with females reporting higher levels of fear in response to this subscale (see Fig. 2). There was little to no evidence to suggest that injection frequency, diabetes type, age, examination frequency or time since diagnosis played a meaningful role in explaining fear of sharp objects. This suggests that, unlike fears directly related to injections, fear of sharp objects is driven more by stable individual differences than medical experience.

3.3. Fear of examinations and symptoms scale

Fear related to medical examinations and physical symptoms was again primarily associated with sex. Detailed statistical results are shown in Table 2. The model indicated that males and females differed in their reported fear levels, with females scoring higher on this subscale

Table 2
Detailed statistical results for the selected models, presented separately for the five Medical Feas Scale subscales, and follow-up pairwise comparisons for differences in diabetes mellitus type.

MFS subscale	Coefficient	P _(incl data)	BF _{inclusion}	Mean	SD	95% Credible Interval	
						Lower	Upper
Injection and Blood Draws	Intercept	1.000	1.000	1.892	0.134	1.639	2.194
	Injection frequency	0.592	1.448	−0.217	0.223	−0.618	0.000
	Diabetes type	0.694	2.269	0.436	0.366	−0.002	1.015
	Sex	0.207	0.262	0.037	0.190	−0.226	0.629
	Age	0.782	3.578	−0.020	0.014	−0.042	0.000
	Examination frequency	0.237	0.310	−0.028	0.089	−0.332	0.051
Sharp Objects	Time since diagnosis	0.219	0.281	0.003	0.010	−0.013	0.033
	Intercept	1.000	1.000	1.937	0.132	1.668	2.195
	Injection frequency	0.278	0.385	−0.039	0.095	−0.288	0.066
	Diabetes type	0.388	0.634	0.119	0.194	−0.003	0.622
	Sex	0.940	15.804	1.164	0.474	0.000	1.882
	Age	0.258	0.348	−0.003	0.007	−0.022	0.002
Examinations and Symptoms	Examination frequency	0.218	0.278	−0.027	0.086	−0.312	0.008
	Time since diagnosis	0.174	0.211	<0.001	0.008	−0.026	0.009
	Intercept	1.000	1.000	8.239	0.187	7.883	8.621
	Injection frequency	0.133	0.153	−0.023	0.084	−0.306	0.011
	Diabetes type	0.098	0.109	0.009	0.098	−0.139	0.279
	Sex	0.697	2.300	1.064	0.826	0.000	2.292
Blood	Age	0.083	0.091	<0.001	0.004	−0.005	0.008
	Examination frequency	0.101	0.112	−0.013	0.072	−0.292	0.013
	Time since diagnosis	0.090	0.099	<0.001	0.007	−0.013	0.009
	Intercept	1.000	1.000	2.386	0.166	2.094	2.750
	Injection frequency	0.285	0.398	−0.072	0.158	−0.541	0.021
	Diabetes type	0.800	4.009	0.532	0.340	0.000	1.038
Mutilation	Sex	0.215	0.274	0.113	0.309	−0.005	1.131
	Age	0.380	0.612	−0.008	0.013	−0.036	<0.001
	Examination frequency	0.152	0.179	−0.010	0.077	−0.190	0.164
	Time since diagnosis	0.186	0.228	0.004	0.012	−0.005	0.046
	Intercept	1.000	1.000	8.701	0.197	8.339	9.087
	Injection frequency	0.242	0.319	−0.047	0.144	−0.496	0.021
	Diabetes type	0.641	1.783	0.443	0.406	0.000	1.108
	Sex	0.507	1.027	0.617	0.734	0.000	1.994
	Age	0.164	0.196	0.001	0.006	−0.003	0.024
	Examination frequency	0.209	0.264	0.047	0.137	−0.052	0.449
	Time since diagnosis	0.207	0.261	0.005	0.016	−0.009	0.051

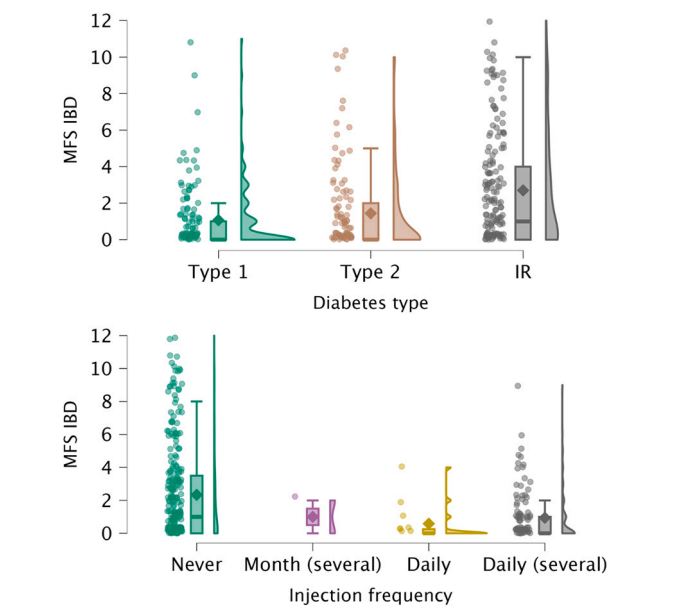


Fig. 1. The differences between the diabetes mellitus and injection frequency groups are displayed on separate panels on the Injection and Blood Draws (IBD) subscale of the Medical Fear Survey (MFS). Diamonds represent the mean.

(see Fig. 3). However, none of the medical experience variables — including injection frequency, examination frequency, diabetes type or time since diagnosis — showed meaningful evidence of an association

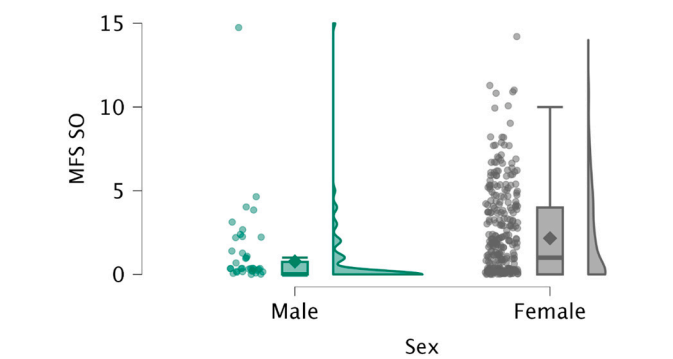


Fig. 2. Sex differences on the Sharp Objects (SO) subscale of the Medical Fear Survey (MFS). Diamonds represent the mean.

with fear in this domain. Age also did not emerge as a relevant predictor. Overall, fear of examinations and symptoms appeared largely independent of the frequency or duration of medical exposure.

3.4. Fear of blood scale

The pattern of fear of blood was similar to that of fear of injections and blood draws, though somewhat more selective. Detailed statistical results are shown in Table 2. The results provided evidence for including diabetes type as a predictor. As with injections, individuals with type 1 or type 2 diabetes tended to report less fear of blood than those with insulin resistance (see Fig. 4). Injection frequency showed weaker and less consistent results in this model, and the remaining predictors — sex,

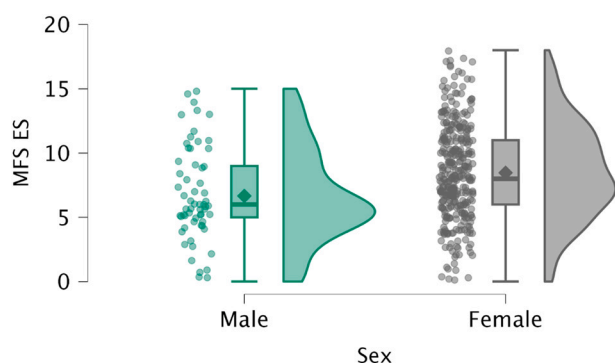


Fig. 3. Sex differences on the Examinations and Symptoms (ES) subscale of the Medical Fear Survey (MFS). Diamonds represent the mean.

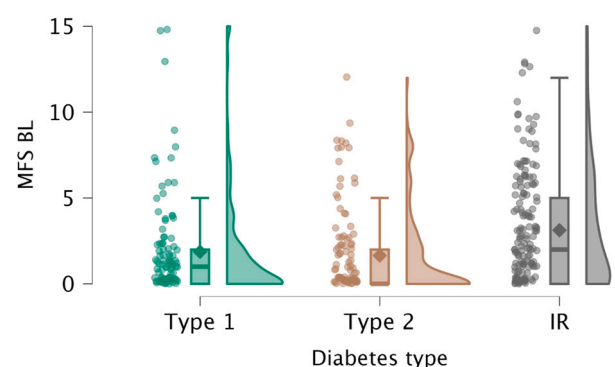


Fig. 4. The differences between the diabetes mellitus groups on the Blood (BL) subscale of the Medical Fear Survey (MFS). Diamonds represent the mean.

age, examination frequency and time since diagnosis — did not meaningfully contribute towards explaining fear of blood once diabetes type had been accounted for.

3.5. Fear of mutilation scale

Regarding fear of mutilation, none of the predictors showed strong or consistent evidence of association. Detailed statistical results are shown in Table 2. All variables, including injection frequency, diabetes type, sex (see Fig. 5), age, examination frequency and time since diagnosis, showed low inclusion probabilities, indicating that the data favored models without these predictors. This pattern is consistent with the idea that fear of mutilation is relatively independent of routine medical exposure, reflecting a more generalized or symbolic fear that cannot be easily modified by repeated medical experiences.

4. Discussion

The primary motivation behind our study was to gain a better understanding of the mechanisms through which frequent exposure to medical stimuli may reduce fear responses, an effect commonly referred to as fear inoculation. By focusing on distinct domains of medical fears, we aimed to explore whether experience reduces fear, and which types of experience influence specific fears. Importantly, we tested these associations in a real-world setting using a DM patient population, a unique group that routinely engages in medical procedures. This approach enabled us to examine whether exposure to everyday procedures such as injections and examinations is linked to reduced fear and, if so, to what extent these effects generalize across different fear domains. Across the five domains of medical fear, experience with injections and diabetes-related treatment was selectively associated with reductions in fear across the five domains of medical fear. This was

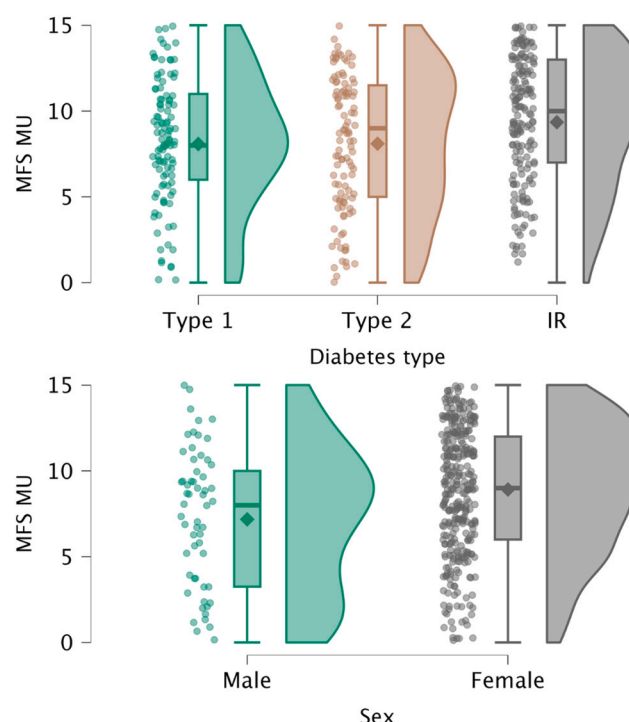


Fig. 5. The differences between the diabetes mellitus groups and sex differences are displayed on separate panels on the Mutilation (MU) subscale of the Medical Fear Survey (MFS). Diamonds represent the mean.

particularly evident in domains involving direct contact with needles, blood, or invasive procedures. In contrast, fears relating to examinations, sharp objects and mutilation were less consistently linked to medical exposure, being more strongly influenced by sex differences. Overall, repeated exposure appears to reduce fear primarily in domains closely matching the medical procedures experienced, rather than producing a general reduction in all forms of medical fear. Rather than demonstrating a causal, fear-reducing effect of medical exposure, the present findings indicate systematic associations between different forms of medical experience and domain-specific medical fears. While these patterns are consistent with fear inoculation accounts, they are also compatible with reverse or bidirectional processes.

Our findings highlight the central role of diabetes type in shaping medical fears. They suggest that broader, long-term patterns of medical exposure are more influential than the frequency of any single procedure. Type of diabetes emerged as a consistent predictor of lower fear across three domains—injections and blood draws, blood, and sharp objects—with individuals diagnosed with Type 1 or Type 2 diabetes generally reporting lower fear than those with insulin resistance. These differences likely reflect cumulative differences in disease management. Type 1 and many Type 2 patients undergo more invasive, repeated and often self-administered medical procedures over extended periods (Haller et al., 2005; Petersmann et al., 2019). Notably, the insulin-resistant group is a distinct clinical population that has substantially less experience of invasive and self-administered medical procedures than individuals with type 1 or type 2 diabetes. This is likely to contribute to the higher levels of fear observed in several areas. Insulin resistance is usually managed with less invasive interventions, particularly in the early stages (Ogawa et al., 2022). This pattern supports the idea that sustained, multifaceted medical exposure reduces fear in related areas, as proposed by fear inoculation theories (Coelho et al., 2021; Coelho & Purkis, 2009; Fyer, 1998).

At the same time, the results suggest a domain-specific effect of injection frequency. More frequent injections were only associated with lower fear on the Injection and Blood Draws subscale, with no

meaningful associations observed for the other fear domains. This suggests that repeated exposure primarily reduces fear of stimuli that closely match the experienced procedure rather than producing a generalized reduction in medical fear. This corroborates earlier research in related fields with humans (Birkás et al., 2023; Coelho et al., 2021; Doogan & Thomas, 1992; Kiss et al., 2022) and monkeys (Parker et al., 2004), such as a previous study (Zsido et al., 2025) that showed that fear of injections (and associated pain) is an important factor in the development of dental fear and anxiety; however, previous benign experiences provide protection. However, the case of DM is different because patients have little choice in the matter. If they do not overcome their fears, more severe consequences await. A previous review (Fu et al., 2009) noted that poor compliance with treatment, which is often caused by fear of injections, leads to poor glycemic control, clinical complications, psychological comorbidities, poor general well-being, health issues, and an increased risk of mortality. The domain-specific pattern of results may suggest that reducing fear is closely tied to proximal, stimulus-bound cues, such as needles and blood, rather than to more distal, contextual cues associated with medical settings, such as examinations or clinical environments (Kevin Chapman & DeLapp, 2014; Olatunji et al., 2007). Although frequent contact with highly salient stimuli linked to tissue damage is a key feature of diabetes-related exposure, this may not generalize sufficiently to fears elicited by anticipatory or contextual aspects of medical care. This distinction helps to explain why associations were observed for fear of injections but not for fear of examinations or symptoms. Our results also indicate that routine contact with healthcare settings (such as attending check-ups) or the mere passage of time since diagnosis is insufficient to reduce medical fears in the absence of repeated, hands-on experience of more intensive medical procedures, especially when self-administered.

Women reported significantly higher levels of fear than men across several domains. This is consistent with a substantial body of literature indicating that women tend to report higher levels of specific fears and phobias than men in various domains (Campbell et al., 2016; Cornelius & Averill, 1983; Kessler et al., 2005; Kiss et al., 2022; Wani et al., 2014). Our results indicate that the pattern of associations between medical experience and fear was comparable for both sexes, despite women generally reporting higher levels of fear. In other words, although women report higher levels of fear overall, the mechanisms through which experience reduces fear appear to be equally effective for both sexes. While the present data do not permit conclusions about treatment efficacy, this pattern is consistent with the idea that exposure-based mechanisms may function similarly in both sexes, even when baseline fear levels differ. This is important because sex differences exist in the prevalence of DM, with more men than women estimated to have the condition (Rathmann et al., 2003). Furthermore, the fact that age did not emerge as a predictive factor in any of the models, combined with sex differences, means that the results may also apply to specific forms of DM, such as gestational DM, which only affects women of a certain age. Indeed, over 40% of pregnant women are afraid of needles (Feitosa et al., 2013). This opens up the possibility of studying the association between medical fears and past experience in samples that are not age- and gender-matched, as well as assessing how DM education may affect fear and knowledge in a diverse population.

Some limitations should be noted. Firstly, participants were primarily recruited through online forums and social media groups related to diabetes. This may have introduced self-selection bias, as individuals active in such communities are likely to be more engaged in their healthcare and less averse to medical procedures. This may limit the generalizability of the findings to less engaged patient populations. Secondly, pain intensity and pain sensitivity were not assessed despite their potential role in shaping fear of injections and other invasive procedures. Thirdly, the cross-sectional design precludes conclusions about causality. Although the findings are discussed within a fear inoculation framework, reverse or bidirectional processes, such as individuals with higher medical fear avoiding invasive regimens, cannot

be ruled out. Longitudinal and experimental studies are needed to clarify these mechanisms. Additionally, survival or adherence bias cannot be ruled out. Individuals with severe needle phobia may be less likely to initiate or persist with insulin therapy, meaning they may be under-represented in groups with higher injection exposure.

In conclusion, our study clarifies the relationship between different forms of medical experience and distinct domains of medical fear. By breaking down medical fears into their core components and leveraging a patient population with natural exposure demonstrated that diabetes type was the most consistent predictor of lower fear. Type 1 and Type 2 diabetes were both associated with reduced fear across multiple domains, including injections and blood draws, blood, and sharp objects. This pattern suggests that the sustained invasive medical exposure that is characteristic of long-term diabetes management may generalize across related fear domains. By contrast, injection frequency had a more limited effect, predicting lower fear only for injections and blood draws, and not for other medical procedures. Neither examination frequency nor time since diagnosis was meaningfully associated with fear in any domain. Together, these findings support a domain-specific fear inoculation account, emphasizing that achieving broad reductions in medical fear depends more on the overall intensity of medical exposure than on the repetition of isolated procedures. From a clinical perspective, this highlights the potential value of exposure-based interventions for reducing medical fears, particularly for individuals who tend to avoid situations that trigger their fears. It is important to distinguish between the type of exposure examined in this study and exposure in therapeutic contexts. The repeated medical procedures experienced by individuals with diabetes reflect exposure driven by necessity, rather than structured exposure guided by clinicians aimed at reducing fear. Therefore, the present findings should not be interpreted as evidence that compulsory medical exposure is equivalent to therapeutic fear inoculation. Rather, they suggest that repeated exposure in the real world, as experienced in disease management, may be linked to lower fear in closely related domains. Furthermore, identifying which experiences have protective effects and in which fear domains can help healthcare providers design patient-centered care strategies that minimize distress and improve compliance. DM patients, particularly those who regularly self-inject, provide a valuable model for understanding how everyday medical routines can contribute to long-term emotional resilience in the face of medical stressors.

CRedit authorship contribution statement

Andras N. Zsido: Writing – original draft, Visualization, Funding acquisition, Formal analysis, Conceptualization. **Fanni Óry:** Writing – review & editing, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Szidalsz Ágnes Teleki:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization. **Botond László Kiss:** Writing – review & editing, Visualization, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Ethical approval

Ethics approval was obtained from the Hungarian United Ethical Review Committee for Research in Psychology and the Scientific and Research Ethics Committee of the Health Sciences Council.

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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

The dataset supporting the conclusions of this article is available in the Open Science Framework repository: <https://osf.io/4dap5/>.

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