Eduvest – Journal of Universal Studies
Volume 5 Number 10, October, 2025
p- ISSN 2775-3735- e-ISSN 2775-3727

Probiotics and Vitamin D for Gastrointestinal Damage in Burn Injury

Gracia Widia Putri, I Gusti Putu Hendra Sanjaya, I Gusti Ayu Sri Mahendra Dewi, Agus Roy R.H. Hamid, Putu Anda Tusta Adiputra
RSUP Ngoerah, Indonesia
Email: graciawidiaputri@gmail.com, hendrasanjaya@unud.ac.id, mahendradewi@rocketmail.com, agusroyrusly@unud.ac.id, andatusta@yahoo.com

ABSTRACT

Curling's ulcer, a stress-induced gastrointestinal injury, commonly occurs in patients with major burns due to ischemia and mucosal necrosis. Complications may include perforation, hemorrhagic shock, and death. While standard treatments involve PPIs, sucralfate, and early enteral feeding, probiotics may help restore gut microbiota, and vitamin D can reduce inflammation and dysbiosis. However, studies on their combined efficacy remain limited, particularly in Indonesia. This research aims to evaluate whether oral probiotics and vitamin D reduce TNF-α levels and gastrointestinal damage in Wistar rats with major burns. The study employed an experimental design using 32 Wistar rats with 25% TBSA burns. Subjects were divided into four groups: control (K), probiotics only (P1), vitamin D only (P2), and probiotics + vitamin D (P3). Interventions were administered for two weeks. Measured parameters included blood and tissue TNF-α levels, as well as gastric and intestinal histopathology. Data were analyzed using SPSS. Results showed that group P3 had the lowest tissue TNF-α levels (136.11 ± 50.14; p = 0.046) and intestinal mucosal thickness (914.54 ± 170.08; p = 0.007). Indicators of gastric damage—macrophage count, necrosis, and bleeding—were significantly reduced in the treatment groups (p = 0.000). No significant difference was observed in villi width (p = 0.974). Combined oral probiotics and vitamin D significantly reduced tissue TNF-α levels and gastrointestinal damage, with better outcomes than single-agent treatments. This combination therapy shows potential as an adjunctive approach for gastrointestinal protection in major burns.

KEYWORDS *Stress ulcer, probiotic, vitamin D, TNF- α, intestines mucosa thickness*

INTRODUCTION

Burn injury remains a significant health concern worldwide due to its rising incidence, morbidity, and mortality rates. A major burn injury is defined as involving more than 20% of the total body surface area (TBSA). Major burns can trigger a systemic inflammatory response that affects various organs, including the gastrointestinal (GI) tract. One such complication is Curling's ulcer, a form of stress ulcer that can occur in patients with major burns (Burgess et al., 2022; Hoppenz et al., 2021; Jordan et al., 2022; Kim & Drew, 2022; Shpichka et al., 2019; Wang et al., 2018; Weststrate et al., 2019). This condition can lead to severe GI hemorrhage, perforation, anemia, and even death if not properly treated.

The incidence of Curling's ulcer is not specifically documented, but it is estimated to occur in nearly all burn patients with TBSA greater than 20%. Globally, about 66% of burn cases are found in low- to middle-income countries, particularly in Africa and Southeast Asia. In Indonesia, burn prevalence is approximately 2.2%, with the highest reported cases occurring in Bali (6.8%).

The pathogenesis of Curling's ulcer involves oxidative stress, overproduction of gastric acid, and elevated inflammatory mediators such as TNF-α. Current management strategies

include proton pump inhibitors (PPIs), sucralfate, early enteral nutrition, and endoscopic interventions (Inadomi & Fendrick, 2005; Nabi & Reddy, 2016; Naidoo, 2016; Shin & Kim, 2013; Turner et al., 2022; Zagari et al., 2018). However, preventive approaches using antioxidants and anti-inflammatory agents like probiotics and vitamin D have gained attention. Probiotics can help restore mucosal integrity and modulate immune responses, while vitamin D exerts anti-inflammatory effects and supports gut microbiota balance (Abboud et al., 2020; Ghaderi et al., 2019; Pagnini et al., 2021; Wu et al., 2015).

Despite promising results, studies evaluating the combined role of probiotics and vitamin D in preventing GI injury in major burns remain limited, particularly in Indonesia. Several previous studies have explored their potential benefits in managing burn-related complications, yet their synergistic effects are still poorly understood. Masoumi et al. (2023) investigated the impact of probiotic administration on inflammatory responses in patients with severe thermal burns and found that probiotics could accelerate wound healing and modulate inflammation. However, the study was limited by a small sample size, short follow-up period, and lack of focus on gastrointestinal complications such as Curling's ulcer. Similarly, Ghadimi et al. (2025) examined the effects of vitamin D3 supplementation on burn recovery, reporting improvements in insulin regulation and wound healing outcomes. Nevertheless, the study did not assess vitamin D's role in preventing GI mucosal injury or its interaction with gut microbiota.

The current study aims to evaluate the combined effect of probiotics and vitamin D supplementation in preventing GI injury, maintaining mucosal integrity, and modulating inflammatory responses in patients with burns covering more than 20% of TBSA. The anticipated benefit of this research is to provide empirical evidence supporting an integrative, gut-targeted preventive approach that could reduce gastrointestinal morbidity, improve patient recovery outcomes, and contribute to the development of updated clinical guidelines for stress ulcer prevention in burn care.

METHOD

This study is experimental research using post-test only control group design. The samples were wistar rats that are given major burn injury. Samples were then assessed the TNF-α and GI damage. The samples were taken at period of November 2024 up to February 2025. The inclusion criteria include male wistar rats, healthy, feedable, aged around two up to three months, and body weight of 180 up to 220 grams. Exclusion criteria include diseased rats and having anatomy or physiological abnormality. Rats were then divided into four groups. All rats were inflicted with major burn injury. Control group or P1 receives no treatment. P2 group received vitamin D for 2 weeks, P3 group received probiotics for 2 weeks, and P4 group received both in 2 weeks. Every group has eight rats, with a total of 32 rats for all groups.

All rats received same food supply and same cage condition. After 8 days of rats' adaptation, they were administered third grade burn injury as wide as 25% TBSA. Then their injuries were then treated with sterile saline continously amd treated with sufratulle and sterile gauze. The control group (P1) were not given probiotic or vitamin D. Group P2 were given vitamin D as much as 10mcg/kgBW for 2 weeks, whereas group P3 received Lactobacillus spp. Probiotic 109/CFU/kgBW/day for 2 weeks. Group P4 received both treatments for 2 weeks.

After 2 weeks, 3cc of blood and intestineals from each rat were taken to analyze the TNF- α. Rats' stomach was also taken and analyzed using microscope to analyze the tissue destruction. Rats sample were then sacrificed.

The data obtained in this study were processed using computer software. Initially, all collected data were entered into Microsoft Excel for sample characteristic entry and subsequently transferred to SPSS version 26.0 for Windows for statistical analysis. Normality testing was conducted to assess the distribution pattern of numerical variables. Descriptive analysis was performed to characterize the research subjects and study variables. Numerical variables were presented as means and standard deviations, while categorical variables were described using relative frequencies and summarized in univariate distribution tables. To evaluate the association between modalities. One-way ANOVA was applied when the data were normally distributed; otherwise, the Kruskal-Wallis test was used. If the results were significant, Post Hoc Mann-Whitney test were used. Categorical datas were tested using Chi-Square tests. All statistical analyses were performed using SPSS version 26.0, with significance set at $p < 0.05$ and a 95% confidence interval.

RESULT AND DISCUSSION

There are 32 samples that were done during the study period. The subjects' characteristics can be observed in Table 1.

Table 1. Characteristics of Samples

Variable	n	Mean	SD	Median	Min-Max
TNF-α Content					
Blood	32	203,58	24,459	200,83	155,97 – 275,69
Tissue	32	180,59	54,183	187,91	83,19 – 270,69
Stomach					
Necrosis	32	0,80	0,597	0,60	0,20 - 200
Bleeding	32	0,50	0,424	0,40	0,00 – 1,80
Macrophage count	32	55,43	31,384	49,50	14,00 – 136,00
Small Intestine					
Mucous thickness	32	1052,92	187,975	1125,44	465,23 – 1340,21
Villy width	32	214,44	56,853	200,13	95,77 – 386,17
PMN count	32	1,05	0,709	1,00	0,00 – 2,40

TNF-α: Tumor necrosis factor alpha; PMN: polymorphonuclear cells

Several variables did not meet normal distribution based on the Shapiro-Wilk test such as: blood TNF-α: Group P1 (p=0.001); villi width: Group P2 (p=0.002); intestinal PMN count: Group P1 (p=0.001) and P3 (p=0.006); Gastric necrosis percentage: Group P2 (p=0.037) and P3 (p=0.000). All other groups and parameters showed normally distributed data.

Comparative tests were done between the control groups and treatment groups and can be seen in Table 2. Several parameters in this study showed statistically significant differences between the control and treatment groups. A significant reduction in tissue TNF-α levels was observed (p=0.046, One Way ANOVA), with group P3 (probiotic + vitamin D) showing the lowest mean value (136.11 ± 50.14) compared to the control group K (185.45 ± 46.10), P1 (probiotic only, 201.52 ± 55.80), and P2 (vitamin D only, 199.30 ± 45.38). This suggests a notable anti-inflammatory effect of the combined intervention. In addition, intestinal mucosal thickness differed significantly among groups (p=0.007, One Way ANOVA). The control group had the highest mean thickness (1189.53 ± 88.07), while group P3 again showed the lowest value (914.54 ± 170.08), indicating improved preservation of mucosal

structure with the combined therapy. Further, gastric damage markers including macrophage count, necrosis, and bleeding have demonstrated highly significant differences (p=0.000, Kruskal-Wallis test).

Table 2. Comparative of Each Groups

Variables	Groups	N	Mean	SD	CI95%	p
TNF-α in blood	K	8	213,64	34,437	184,86 – 242,44	0,238[a]
	P1	8	211,07	23,262	191,63 – 230,52	
	P2	8	196,87	12,734	186,23 – 207,52	
	P3	8	192,74	19,866	176,13 – 209,35	
TNF-α in stomach	K	8	185,45	46,101	146,91 – 223,99	0,046[b]*
	P1	8	201,52	55,802	154,88 – 248,18	
	P2	8	199,30	45,376	161,37 – 237,24	
	P3	8	136,11	50,138	94,19 – 178,03	
Small intestine' thickness	K	8	1189,53	88,069	1115,90 – 1263,1	0,007[b]*
	P1	8	1122,71	98,394	1040,46 – 1204,9	
	P2	8	984,90	236,750	786,97 – 1182,83	
	P3	8	914,54	170,077	772,35 – 1056,73	
Small intestines villi width	K	8	218,71	64,469	164,81 – 272,61	0,974[a]
	P1	8	207,36	57,259	159,49 – 255,23	
	P2	8	219,44	70,532	160,48 – 278,41	
	P3	8	212,27	42,341	176,87 – 247,67	
Small intestines' PMN cell count	K	8	1,85	0,410	1,51 – 2,19	0,000[a]*
	P1	8	1,47	0,212	1,30 – 1,65	
	P2	8	0,67	0,319	0,41 – 0,94	
	P3	8	0,22	0,198	0,06 – 0,39	
Stomach necrosis percentage	K	8	1,60	0,320	1,33 – 1,87	0,000[a]*
	P1	8	1,02	0,291	0,78 – 1,27	
	P2	8	0,37	0,128	0,27 – 0,48	
	P3	8	0,22	0,070	0,17 – 0,28	
Stomach bleeding percentage	K	8	1,07	0,465	0,69 – 1,46	0,000[b]*
	P1	8	0,37	0,166	0,24 – 0,51	
	P2	8	0,35	0,141	0,23 – 0,47	
	P3	8	0,22	0,059	0,09 – 0,36	
Stomach macrophage count	K	8	95,37	19,234	79,29 – 111,46	0,000[b]*
	P1	8	70,12	8,425	63,08 – 77,17	
	P2	8	33,62	6,501	28,19 – 39,06	
	P3	8	22,62	5,926	17,67 – 27,58	

*statistically significant (p<0.05) using [(a)]*Kruskal-Wallis* or [(b)]*One Way ANOVA*
TNF-α: Tumor necrosis factor alpha; PMN: polymorphonuclear

Post hoc analysis in Table 3 showed significantly lower tissue TNF-α levels in group P3 compared to P1 (p = 0.013) and P2 (p = 0.016). The 95% confidence intervals did not include zero, confirming that the combined intervention was more effective than either probiotic or vitamin D alone.

Table 3. Post Hoc Test for TNF- α Content

Group		Mean differences	SE	p	CI95% Min	CI95% Max
Tissue						
K	P1	-16,07637	24,76417	0,522	-66,8035	34,6507
K	P2	-13,85425	24,76417	0,580	-64,5814	36,8729
K	P3	49,34000	24,76417	0,056	-1,3871	100,0671
P1	P2	2,22213	24,76417	0,929	-48,5050	52,9492
P1	P3	65,41637*	24,76417	0,013	14,6893	116,1435
P2	P3	63,19425*	24,76417	0,016	12,4671	113,9214

*Stastically significant (p<0.05) using LSD Post hoc test

Post hoc analysis revealed significant differences in gastric damage parameters in Table 4. For gastric necrosis, all comparisons between the control group and treatment groups (P1, P2, P3) were significant (all p = 0.000), as were comparisons between P1–P2 and P1–P3. However, P2–P3 showed no significant difference (p = 0.200). For gastric bleeding, all control vs. treatment comparisons were highly significant (p = 0.000), while no significant differences were found among the treatment groups. In gastric macrophage count, most group comparisons were significant, except for P2 vs. P3 (p = 0.063), which was not.

Table 4. Post Hoc Test for Stomach Damage

Group		Mean differences	SE	p	IK95% Min	IK95% Max
Necrosis						
K	P1	0,57500*	0,11437	0,000	0,3407	0,8093
K	P2	1,22500*	0,11437	0,000	0,9907	1,4593
K	P3	1,37500*	0,11437	0,000	1,1407	1,6093
P1	P2	0,65000*	0,11437	0,000	0,4157	0,8843
P1	P3	0,80000*	0,11437	0,000	0,5657	1,0343
P2	P3	0,15000	0,11437	0,200	-0,0843	0,3843
Bleeding						
K	P1	0,70000*	0,13513	0,000	0,4232	0,9768
K	P2	0,72500*	0,13513	0,000	0,4482	1,0018
K	P3	0,85000*	0,13513	0,000	0,5732	1,1268
P1	P2	0,02500	0,13513	0,855	-0,2518	0,3018
P1	P3	0,15000	0,13513	0,276	-0,1268	0,4268
P2	P3	0,12500	0,13513	0,363	-0,1518	0,4018
Macrophage count						
K	P1	25,25000*	5,69186	,000	13,5907	36,9093
K	P2	61,75000*	5,69186	,000	50,0907	73,4093
K	P3	72,75000*	5,69186	,000	61,0907	84,4093
P1	P2	36,50000*	5,69186	,000	24,8407	48,1593
P1	P3	47,50000*	5,69186	,000	35,8407	59,1593
P2	P3	11,00000	5,69186	,063	-,6593	22,6593

*statistically significant (p<0.05) using Post Hoc LSD test

Post hoc analysis in Table 5 of intestinal damage parameters showed significant differences in mucosal thickness between group K and P2 (p = 0.016), K and P3 (p = 0.002), and between P1 and P3 (p = 0.015). Other group comparisons for this parameter were not significant. For PMN count, all comparisons—both between control and treatment groups (K vs P1, P2, and P3) and among treatment groups (P1 vs P2, P1 vs P3, P2 vs P3)—showed statistically significant differences (all p < 0.05), indicating consistent reductions in inflammation with treatment.

Table 5. Post Hoc Test of Intestinal Damage

Groups		Mean differences	SE	p	IK95% Min	IK95% Max
Mucous thickness						
K	P1	66,81388	80,00574	,411	-97,0704	230,6982
K	P2	204,63138*	80,00574	,016	40,7471	368,5157
K	P3	274,98888*	80,00574	,002	111,1046	438,8732
P1	P2	137,81750	80,00574	,096	-26,0668	301,7018
P1	P3	208,17500*	80,00574	,015	44,2907	372,0593
P2	P3	70,35750	80,00574	,387	-93,5268	234,2418
PMN cell count						
K	P1	0,37500*	0,14895	,018	0,0699	0,6801
K	P2	1,17500*	0,14895	,000	0,8699	1,4801
K	P3	1,62500*	0,14895	,000	1,3199	1,9301

P1	P2	0,80000*	0,14895	,000	0,4949	1,1051
P1	P3	1,25000*	0,14895	,000	0,9449	1,5551
P2	P3	0,45000*	0,14895	,005	0,1449	0,7551

*Stastically significant ($p<0.05$) using Post Hoc LSD test
PMN: polumorphonuclear

Figure 1 illustrates the gastric histopathology of Wistar rats stained with Hematoxylin-Eosin (H&E) across the control (A) and treatment groups: P1 (B), P2 (C), and P3 (D). The control group (A) showed structural damage, including mucosal necrosis, prominent inflammatory cell infiltration, and bleeding. Group P1 (B) shows mild improvement with few inflammation and early tissue regeneration. Group P2 (C) showed recovery, with improved mucosal thickness and less tissue damage. Group P3 (D) shows the best histological structure, with better mucosal integrity, reduced inflammation, and optimal epithelial regeneration. These findings suggest that the combined probiotic and vitamin D treatment in group P3 had the most significant effect on gastric tissue following major burn injury.

Figure 2 shows intestinal histology of rats post-burn. The control group (A) shows mucosal thinning, villi atrophy, and extreme inflammation. Group P1 (B) showed improvement in structure but still inflammation. Group P2 (C) showed better mucosal preservation and reduced inflammation. Group P3 (D) showed the best outcome, with thicker mucosa, longer villi, and minimal inflammatory. This shows group P3 has the best appearances.

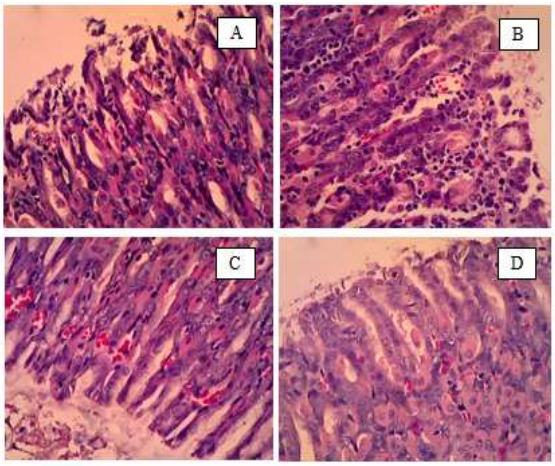

Figure 1. Stomach Histopatholgy in Wistar rats with Hematoxylin-Eosin (H&E) and 400x magnification. (a) Control group, (b) P1 group, (c) P2 group, and (d) P3 group

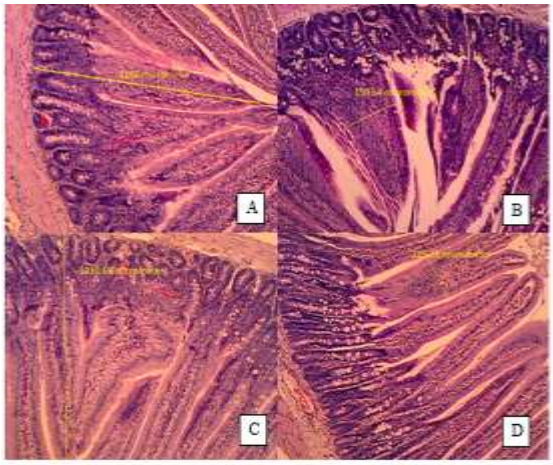

Figure 2. Small Intestines Histopatholgy in Wistar rats with Hematoxylin-Eosin (H&E) and 400x magnification. (a) Control group, (b) P1 group, (c) P2 group, and (d) P3 group

Major burn injuries trigger a complex systemic inflammatory response, marked by elevated pro-inflammatory cytokines such as TNF-α. This cytokine increases vascular permeability, recruits immune cells, worsens tissue necrosis, and disrupts gastrointestinal homeostasis by enhancing intestinal permeability and promoting bacterial translocation. Controlling TNF-α production is essential to reduce inflammation and prevent further tissue damage. In this study, the administration of probiotics and vitamin D was evaluated for their effectiveness in reducing TNF-α levels and gastrointestinal injury in Wistar rats with major burns [13].

Results showed no significant difference in blood TNF-α levels across groups; however, tissue TNF-α levels were significantly lower in the group receiving both probiotics and vitamin D (P3), compared to control and single-intervention groups. Group P3 had a mean TNF-α level of 136.11 ± 50.14, significantly lower than the control group ($p = 0.046$). This supports previous findings that the combined use of probiotics and vitamin D has a stronger anti-inflammatory effect than either alone [14].

Probiotics reduce TNF-α via gut microbiota modulation, enhancement of epithelial integrity, and suppression of NF-κB signaling [15,16], while vitamin D regulates immunity by downregulating NF-κB and strengthening epithelial barriers through tight junction proteins [14,16]. These synergistic mechanisms explain the superior effect of the combined treatment. The lack of significance in blood TNF-α may be due to its transient peak within 24 hours post-trauma, while tissue TNF-α remains elevated for weeks [17,18].

This study demonstrated that the combination of probiotics and vitamin D was effective in reducing gastrointestinal injury in Wistar rats with major burns. Severe burns often trigger systemic inflammation and gastrointestinal dysfunction, exacerbated by bacterial translocation [19]. Intervention in group P3 significantly reduced gastric necrosis (0.22 vs. 1.60; $p = 0.000$) and inflammation (0.22 vs. 1.65; $p = 0.000$) compared to the control group. These findings align with previous evidence showing that probiotics inhibit NF-κB signaling and promote anti-inflammatory cytokine production, while vitamin D strengthens intestinal tight junctions.

The tissue TNF-α level in group P3 (136.11 ± 50.14) was significantly lower than in the control group (185.45 ± 46.10; $p = 0.046$), supporting the synergistic anti-inflammatory effect. Additionally, the intestinal mucosa in group P3 was thinner than that of the control (914.54 vs. 1189.53; $p = 0.007$), indicating protection against inflammation-induced hypertrophy. Clinically, this combined intervention holds potential as a supportive therapy to prevent gastrointestinal complications in severe burn patients, in line with previous studies.

CONCLUSION

In Wistar rats with major burns, oral administration of probiotics and vitamin D demonstrated significant gastrointestinal recovery effects, with the combination therapy yielding the lowest tissue TNF-α levels and markedly reducing gastric damage indicators such as necrosis, bleeding, and inflammation compared to controls. While serum TNF-α levels and villus width showed no significant differences, mucosal thickness in the intestines was significantly lower in intervention groups, suggesting prevention of hypertrophy associated with chronic inflammation. These findings support the synergistic potential of probiotics and vitamin D as adjunct therapies for systemic and gastrointestinal complications in severe burns, and future research should focus on long-term efficacy, underlying mechanisms, and translation to human clinical trials.

REFERENCES

Abboud, M., Rizk, R., AlAnouti, F., Papandreou, D., Haidar, S., & Mahboub, N. (2020). The Health Effects of Vitamin D and Probiotic Co-Supplementation: A Systematic Review of Randomized Controlled Trials. *Nutrients*, *13*(1). https://doi.org/10.3390/nu13010111

Burgess, M., Valdera, F., Varon, D., Kankuri, E., & Nuutila, K. (2022). The Immune and Regenerative Response to Burn Injury. In *Cells* (Vol. 11, Issue 19). https://doi.org/10.3390/cells11193073

Ghaderi, A., Banafshe, H. R., Mirhosseini, N., Moradi, M., Karimi, M. A., Mehrzad, F., Bahmani, F., & Asemi, Z. (2019). Clinical and metabolic response to vitamin D plus probiotic in schizophrenia patients. *BMC Psychiatry*, *19*(1). https://doi.org/10.1186/s12888-019-2059-x

Hoppenz, M., Wendenburg, W., Kaufmann, J., Marathovouniotis, N., & Klein, T. (2021). Pediatric burn injuries. *Padiatrische Praxis*, *96*(1). https://doi.org/10.4037/15597768-1993-2020

Inadomi, J. M., & Fendrick, A. M. (2005). PPI use in the OTC era: Who to treat, with what, and for how long? In *Clinical Gastroenterology and Hepatology* (Vol. 3, Issue 3). https://doi.org/10.1016/S1542-3565(04)00717-7

Jordan, K. C., Di Gennaro, J. L., von Saint André-von Arnim, A., & Stewart, B. T. (2022). Global trends in pediatric burn injuries and care capacity from the World Health Organization Global Burn Registry. *Frontiers in Pediatrics*, *10*. https://doi.org/10.3389/fped.2022.954995

Kim, E., & Drew, P. J. (2022). Management of burn injury. In *Surgery (United Kingdom)* (Vol. 40, Issue 1). https://doi.org/10.1016/j.mpsur.2021.11.006

Masoumi, S., Mahdavi-Roshan, M., Majidiniya, A., Ghaffari, M. E., Pirdastan, S., Hajian, A., & Mobayen, M. (2023). Effect of probiotic administration in inflammatory responses of thermal burns. *European Journal of Inflammation*, *21*. https://doi.org/10.1177/1721727X231167027

Nabi, Z., & Reddy, D. N. (2016). Endoscopic management of gastroesophageal reflux disease: Revisited. In *Clinical Endoscopy* (Vol. 49, Issue 5). https://doi.org/10.5946/ce.2016.133

Naidoo, V. (2016). Proton pump inhibitors. In *SA Pharmaceutical Journal* (Vol. 83, Issue 1). https://doi.org/10.1177/1060028016665641

Pagnini, C., Di Paolo, M. C., Graziani, M. G., & Delle Fave, G. (2021). Probiotics and Vitamin D/Vitamin D Receptor Pathway Interaction: Potential Therapeutic Implications in Inflammatory Bowel Disease. In *Frontiers in Pharmacology* (Vol. 12). https://doi.org/10.3389/fphar.2021.747856

Shin, J. M., & Kim, N. (2013). Pharmacokinetics and pharmacodynamics of the proton pump inhibitors. In *Journal of Neurogastroenterology and Motility* (Vol. 19, Issue 1). https://doi.org/10.5056/jnm.2013.19.1.25

Shpichka, A., Butnaru, D., Bezrukov, E. A., Sukhanov, R. B., Atala, A., Burdukovskii, V., Zhang, Y., & Timashev, P. (2019). Skin tissue regeneration for burn injury. In *Stem Cell Research and Therapy* (Vol. 10, Issue 1). https://doi.org/10.1186/s13287-019-1203-3

Turner, J. P., Thompson, W., Reeve, E., & Bell, J. S. (2022). Deprescribing proton pump inhibitors. *Australian Journal of General Practice*, *51*(11). https://doi.org/10.31128/AJGP-07-22-6497

Wang, Y., Beekman, J., Hew, J., Jackson, S., Issler-Fisher, A. C., Parungao, R., Lajevardi, S. S., Li, Z., & Maitz, P. K. M. (2018). Burn injury: Challenges and advances in burn wound healing, infection, pain and scarring. In *Advanced Drug Delivery Reviews* (Vol. 123). https://doi.org/10.1016/j.addr.2017.09.018

Weststrate, J., Dijkstra, G., Eshuis, J., Gianoli, A., & Rusca, M. (2019). The Sustainable Development Goal on Water and Sanitation: Learning from the Millennium Development Goals. *Social Indicators Research*, *143*(2). https://doi.org/10.1007/s11205-018-1965-5

Wu, S., Yoon, S., Zhang, Y. G., Lu, R., Xia, Y., Wan, J., Petrof, E. O., Claud, E. C., Chen, D., & Sun, J. (2015). Vitamin D receptor pathway is required for probiotic protection in colitis. *American Journal of Physiology - Gastrointestinal and Liver Physiology*, *309*(5). https://doi.org/10.1152/ajpgi.00105.2015

Zagari, R. M., Rabitti, S., Eusebi, L. H., & Bazzoli, F. (2018). Treatment of Helicobacter pylori infection: A clinical practice update. In *European Journal of Clinical Investigation* (Vol. 48, Issue 1). https://doi.org/10.1111/eci.12857