Supplementary Table 2. Analysis of Business Understanding phase based on CRISP-DM methodology in selected studies (N = 125)

Index	Author (Year)	Research objective	Analytical Framework
A1	Marketta Hiissa et al. (2006)	To classify intensive care nursing narratives to improve the utilization of free-text nursing documentation	NI
A2	Manabu Nii et al. (2007)	To classify nursing-care freestyle text to reduce workloads for nursing-care experts	NI
A3	Laurence G. Moseley et al. (2008)	To predict which students are likely to drop out of nursing courses	NI
A4	Alexander Zlotnik et al. (2015)	To forecast emergency department visits and optimize nursing staff allocation	NI
A5	Manabu Nii et al. (2016)	To classify nursing-care texts using word vector representations generated by word2vec to improve nursing-care evaluation	NI
A6	Robert Sherwin et al. (2017)	To identify septic patients in emergency department using a novel computer-based clinical decision support alert system	NI
A7	Shinichiroh Yokota et al. (2017)	To develop a classification system for high fall-risk among inpatients	NI
A8	Jeungok Choi et al. (2018)	To develop a prediction model for depression among community-residing older adults	NI
A9	Stephen I. Gallant et al. (2018)	To predict severe sepsis using only text data	NI
A10	Eliezer Bose et al. (2019)	To identifying critical data elements in nursing documentation	NI
A11	Gerald C. Gannod et al. (2019)	To tailor preference assessments and enhance person-centered care for nursing home residents	NI
A12	Steven G. Johnson et al. (2018)	To map local EHR flowsheet data to standard information models using machine learning approach	NI
A13	Zfania Tom Korach et al. (2019)	To identify risk factors for RRE using unsupervised machine learning on nursing notes	NI
A14	Jae Yung Kwon et al. (2019)	To predict early readmission for diabetes patients	NI
A15	Suzanne S. Sullivan et al. (2019)	To develop a predictive model for 12-month mortality risk among homebound older adults using routinely collected nursing assessment data	DIKW
A16	Maxim Topaz et al. (2019)	To classify fall-related information from clinical notes	NI
A17	Heather Brom et al. (2020)	To identify patients at risk for 30-day readmissions	NI
A18	Roschelle L. Fritz et al. (2020)	To determine if a smart home can detect pain-related behaviors to support automated assessment and intervention for chronic pain patients	NI
A19	Christopher M. Horvat et al. (2020)	To predict pediatric patients at risk for clinical deterioration	NI
A20	Renjie Hu et al. (2020)	To identify top interpersonal and organizational predictors for nurses' willingness to report medication errors	NI
A21	Mireia Ladios-Martin et al. (2020)	To predict the risk of pressure injuries in ICU patients	CRISP-DM
A22	Soo-Kyoung Lee et al. (2020)	To compare machine learning methods for predicting falls in nursing homes	NI
A23	Chen Liang et al. (2020)	To improve root cause analysis of patient safety events through optimized incident classification and information presentation.	NI
A24	David S. Lindberg et al. (2020)	To identify important factors in inpatient fall risk prediction	NI
A25	Jung In Park et al. (2020)	To identify risk factors and predict hospital-acquired CAUTI	KDD
A26	Maxim Topaz et al. (2020)	To predict patient hospitalization and emergency department visits using home healthcare clinical notes.	NI
A27	Dana M. Womack et al. (2020)	To assess the utility of ambient workplace data in predicting registered nurse strain	NI
A28	Ran An et al. (2021)	To classify patients in ICUs based on disease severity and care needs to improve nursing management	NI
A29	Linyan Chen et al. (2021)	To detect distress in cancer patients	NI
A30	Aaron Conway et al. (2021)	To classify apneic events to predict whether they will be prolonged during nurse-administered procedural sedation	NI

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Supplementary Table 2. Continued

Index	Author (Year)	Research objective	Analytical Framework
A31	Alberto Garcés-Jiménez et al. (2021)	To classify patterns in clinical data to predict infectious diseases in nursing home residents	NI
A32	Li Hannaford et al. (2021)	To predict if an undergraduate nursing student will graduate within six college years	NI
A33	Farinaz Havaei et al. (2021)	To identify the most important work environment predictors of nurse mental health	NI
A34	Elizabeth P. Howard et al. (2021)	To classify risk levels and predict 90-day hospital readmissions after discharge to different post-acute care sites	NI
A35	Mingyue Hu al. (2021)	To predict cognitive impairment among elderly individuals with normal cognition	NI
A36	Oleksandr Ivanov et al. (2021)	To improve the accuracy of ESI acuity assignment	NI
A37	Liuqi Jin et al. (2021)	To predict necessary interventions for patients at risk of pressure injury to support early intervention	NI
A38	Jisu Kim et al. (2021)	To predict bleeding events in elderly patients with mechanical valve replacements	NI
A39	Soo-Kyoung Lee et al. (2021)	To predict pressure ulcers in nursing home residents using various machine learning methods	NI
A40	Chia-Hui Liu et al. (2021)	To classify fall risk in inpatients using machine learning models to enhance fall prevention strategies	NI
A41	Tamara G. R. Macieira et al. (2021)	To classify standardized nursing care plan data into meaningful palliative care categories	NI
A42	Takuro Nagata et al. (2021)	To classify skin tear severity categories in digital RGB images	NI
A43	Gojiro Nakagami et al. (2021)	To predict pressure injury development in hospitalized patients	NI
A44	Wenyu Song et al. (2021)	To predict pressure injuries using nursing assessment data	NI
A45	Rumei Yang et al. (2021)	To predict fall occurrences among community-dwelling older adults	NI
A46	Huaqiong Zhou et al. (2021)	To predict 30-day unplanned readmissions in pediatric patients using clinical, administrative, and written discharge documentation data	NI
A47	Yanhong Dong et al. (2022)	To classify psychological distress characteristics distinguishing nurses from other healthcare workers in the Asia-Pacific region during COVID-19	NI
A48	Farinaz Havaei et al. (2022)	To identify workplace factors predicting nurses' quality and safe patient care delivery	NI
A49	Tingting Hu et al. (2022)	To predict the success of oxytocin induced labor outcomes in full-term pregnancy	NI
A50	Shuai Jin et al. (2022)	To predict cancer-associated DVT	NI
A51	Mireia Ladios-Martin et al. (2022)	To create a model that detects the population at risk of falls taking into account fall prevention variable	NI
A52	Young Ji Lee et al. (2022)	To classify ovarian cancer patient and caregiver needs from online health communities using automated model	NI
A53	Anup Kumar Mishra et al. (2022)	To predict fall risk among older adults over a 6-month period using geriatric assessments, gait data, and fall history	NI
A54	Kyoung Ja Moon et al. (2022)	To develop a web-based app for delirium prevention in long-term care facilities and analyze its feasibility and usability	Ahituv IFM
A55	Nikhil Padhye et al. (2022)	To predict the risk of pressure injuries based on entropy measures of abdominal skin temperature	NI
A56	Dongni Qian et al. (2022)	To predict the recurrence risk of diabetes in young and middle-aged patients under a team-based nursing model	NI
A57	Javier Rojo et al. (2022)	To optimize the assessment of older adults' functional profiles by applying feature selection in machine learning models	NI
A58	Jiyoun Song et al. (2022)	To predict hospitalization and emergency department visits during home healthcare	NI

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Supplementary Table 2. Continued

Index	Author (Year)	Research objective	Analytical Framework
A59	Tobias R. Spiller et al. (2022)	To develop a machine learning model for delirium screening in acute care using routinely collected nursing data	NI
A60	Katie Walker et al. (2022)	To predict emergency patient wait times that are applicable to a wide variety of emergency departments	NI
A61	Melyana Nurul Widyawati et al. (2022)	To apply a HITL design using a mobile app to detect pregnancy danger signs early and prevent maternal morbidity and mortality	NI
A62	Jie Xu et al. (2022)	To establish a machine learning-based scoring nomogram for early recognition of likely pressure injuries in an ICU	NI
A63	Olga Yakusheva et al. (2022)	To examine the pattern of association between nurse staffing and hospital readmissions and identify potential "tipping points" where additional staffing no longer improves outcomes	NI
A64	Ayla İ rem Aydın et al. (2023)	To assess postoperative pain in children using computer-assisted facial expression analysis	NI
A65	Rui CHEN et al. (2023)	To construct and validate a risk prediction model for immune checkpoint inhibitor-associated pneumonia to aid in high-risk screening for checkpoint inhibitor-associated pneumonia	NI
A66	Ya-Huei Chen et al. (2023)	To predict inpatient fall risk using machine learning models to enhance safety and reduce the workload for nursing staff	NI
A67	Pei-Yu Dai et al. (2023)	To classify ICU patients' agitation-sedation levels into three categories (oversedation, maintain range, and agitation)	NI
A68	Odai Y. Dweekat et al. (2023)	To predict HAPI and assist with early intervention resource allocation	NI
A69	Juliet Edgcomb et al. (2023)	To improve EHR phenotyping for identifying children with suicide-related emergencies	NI
A70	Ajeet Gajra et al. (2023)	To reduce avoidable emergency department visits and hospital admissions in oncology patients by using patient risk-based prescriptive analytics	PDSA
A71	Farinaz Havaei et al. (2023)	To identify workplace predictors of violence against nurses by patients (Type II) and colleagues (Type III)	NI
A72	Sharon Hewner et al. (2023)	To classify high-need primary care patients into distinct psychosocial phenotypes to support tailored transitional care.	NI
A73	Sunho Im et al. (2023)	To develop a mortality prediction model for ICU	NI
A74	Junglyun Kim et al. (2023)	To identify the suicidal ideation risk group among older adults in rural areas	NI
A75	Seong-Kwang Kim et al. (2023)	To predict nurse turnover in Korea	NI
A76	Hyungbok Lee et al. (2023)	To identify the factors affecting the length of stay in the emergency department for critically ill patients transferred to a regional emergency medical center	NI
A77	Hyungbok Lee et al. (2023)	To predict workplace violence in the emergency department	NI
A78	Lin-Lin Lee et al. (2023)	To measure the area of pressure injuries using hyperspectral imaging and compare it with traditional manual measurement methods	NI
A79	Lingjuan Li et al. (2023)	To describe and predict the risk of severe hypernatremia after surgical resection of craniopharyngioma	NI
A80	Pei-Hung Liao et al. (2023)	To develop and evaluate a sarcopenia nursing guidance mobile app for predicting high-risk populations and enhancing self-care awareness	NI
A81	Sarah R. Martha et al. (2023)	To identify a signature lipid profile from cerebral thrombi in acute ischemic stroke patients using lipidomic and machine learning	NI
A82	Aruna Jothi Shanmugam et al. (2023)	To predict self-medication practices among undergraduate students	NI
A83	Araceli Rodríguez Vico et al. (2023)	To identify post-stroke discharge predictors	NI

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Supplementary Table 2. Continued

Index	Author (Year)	Research objective	Analytical Framework
A84	Zeping Yan et al. (2023)	To construct and validate machine learning models for the early prediction of chronic post-surgical pain (CPSP) among patients undergoing total knee arthroplasty	NI
A85	Metin Yildiz et al. (2023)	To predict health tourism awareness levels in nurses based on intercultural sensitivity and ethnocentrism	NI
A86	Ying Zhou et al. (2023)	To develop a machine learning model to classify depression, anxiety, and apathy in older adults with MCI	NI
A87	Maryam Zolnoori et al. (2023)	To differentiate between patient and nurse language in audio-recorded verbal communication	NI
A88	Young-Taek Park et al. (2024)	To evaluate AI techniques for predicting the annual number of patients in hospitals	NI
A89	Cynthia ABI KHALIL et al. (2024)	To predict HAPI risk	NI
A90	Yaser ALQARRAIN et al. (2024)	To predict HAUTI risk	NI
A91	Komal Aryal et al. (2024)	To predict COVID-19 mortality among nursing home residents before and after vaccine availability	NI
A92	Ranjana Chavan et al. (2024)	To predict B.Sc. Nursing placement outcomes	NI
A93	Xiaomei Chen et al. (2024)	To predict the risk of pressure injuries in children undergoing living donor liver transplantation	NI
A94	Colum Crowe et al. (2024)	To differentiate mobilization patterns of patients pre- and post-intervention	NI
A95	Tian Dai et al. (2024)	To predict postoperative parastomal hernia risk in colorectal cancer patients undergoing permanent colostomy	NI
A96	Martha Duarte et al. (2024)	To predict positive PHQ-2 screening outcomes using the Area Deprivation Index in primary care settings	CRISP-DM
A97	Yu-Fang Guo et al. (2024)	To explore the impact of job crafting and leisure crafting variations on burnout	NI
A98	Rui Jin et al. (2024)	To classify and group health equity information while balancing fairness and performance in predicting antimicrobial treatment likelihood	NI
A99	Arisa Kawashima et al. (2024)	To predict palliative care needs in advanced cancer patients undergoing chemotherapy	NI
A100	Yeonju Kim et al. (2024)	To predict ICU mortality using nursing records	HPM-Expert Signals
A101	Ju Hee Lee et al. (2024)	To develop a machine learning-based prediction model for pressure injury and integrate it into clinical practice	NI
A102	Pin-Chieh Lee et al. (2024)	To develop an association model for lung cancer and environmental hormone high-risk factors using reconstruct nursing assessments	CRISP-DM
A103	Renee C. B. Manworren et al. (2024)	To develop and validate a machine learning model for neonatal pain classification based on facial expressions	NI
A104	Ninon Girardon da Rosa et al. (2024)	To develop a predictive nursing workload classifier model	KDD
A105	Jihye Kim Scroggins et al. (2024)	To classify health problems in patient-nurse verbal communications in home healthcare settings	NI
A106	Lu Shao et al. (2024)	To predict falls among nursing home residents	NI
A107	Madeleine Stanik et al. (2024)	To predict the risk of seizure following an infection in stroke survivors at SNF	NI
A108	Imam Tahyudin et al. (2024)	To predict mortality in stroke patients	NI
A109	Metin Yıldız et al. (2024)	To investigate the effect of nurses' intercultural sensitivity level on xenophobic attitude	NI
A110	Cheng Yu et al. (2024)	To investigate the moderating role of childhood adversity in the relationship between job stress and sleep quality among nurses	NI

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Supplementary Table 2. Continued

Index	Author (Year)	Research objective	Analytical Framework
A111	Wei Zhang et al. (2024)	To develop and validate machine learning models for predicting frailty risk in elderly individuals	NI
A112	Maryam Zolnoori et al. (2024)	To predicting emergency department visits and hospitalizations	NI
A113	Yunping Zhang et al. (2022)	To evaluate the association between nursing factors and the length of stay and readmission rates of elderly residents in nursing homes	NI
A114	Goran Erfani et al. (2024)	To identify patterns and profiles of vaccination hesitancy among nurses to tailor healthcare policies in the UK	NI
A115	Tae Youn Kim et al. (2006)	To develop a predictive model for hospital-acquired pressure ulcers using risk factors	NI
A116	In Sook Cho et al. (2011)	To predict the risk for hospital-acquired pressure ulcers by determining the discriminative ability of a Bayesian network model developed using electronic patient records	NI
A117	Yoko Setoguchi et al. (2016)	To identify key predictors of pressure ulcer development in an acute care setting using an alternating decision tree approach	NI
A118	Mikyung Moon et al. (2017)	To explore factors associated with pressure ulcers in elderly residents of long-term care facilities using decision tree analysis	NI
A119	Pacharmon Kaewprag et al. (2017)	To develop Bayesian network models that predict pressure ulcer incidence in ICU patients using electronic health record data and to identify key risk factors	NI
A120	Xiaohong Deng et al. (2017)	To develop and compare risk-prediction models for hospital-acquired pressure ulcers in ICU patients with the Braden Scale	NI
A121	Hong-Lin Chen et al. (2018)	To develop an artificial neural network model for predicting surgery-related pressure injuries in cardiovascular surgical patients	NI
A122	Hsiu-Lan Li et al. (2019)	To explore and predict key factors associated with pressure injury occurrence in end-of-life patients using nursing data mining techniques	NI
A123	Seul Ki Park (2020)	To develop and compare predictive models for pressure injury occurrence in surgical patients	NI
A124	Sookyung Hyun et al. (2021)	To develop and validate an ICU-specific logistic regression model for predicting hospital-acquired pressure ulcers and to compare its performance with the Braden Scale	NI
A125	Ji-Yu CAI et al. (2021)	To develop an ML-based predictive model for surgery-related pressure injury in cardiovascular surgery patients	NI

Ahituv IFM: The Ahituv model (information flow model); AI: Artificial Intelligence; B.Sc.: Bachelor of Science; CAUTI: Catheter-Associated Urinary Tract Infection; COVID-19: Coronavirus Disease 2019; CPSP: Chronic Post-Surgical Pain; CRISP-DM: Cross-Industry Standard Process for Data Mining; DIKW: Data, Information, Knowledge, Wisdom; DVT: Deep Vein Thrombosis; EHR: Electronic Health Record; ESI: Emergency Severity Index; HAIs: Healthcare-Associated Infections; HAPI: Hospital-Acquired Pressure Injury; HAUTI: Healthcare-Acquired Urinary Tract Infection; HITL: Human-In-The-Loop; HPM-Expert Signals: Healthcare process modeling to phenotype clinician behaviors framework; ICU: Intensive Care Unit; KDD: Knowledge Discovery in Databases; MCI: Mild Cognitive Impairment; NI: No Information; PDSA: Plan-Do-Study-Act; PHQ-2: Patient Health Questionnaire-2; RGB: Red, Green, Blue; RRE: Rapid Response Events; SNF: Skilled Nursing Facility.