Pressure ulcer prevention devices in the management of older patients at risk after hospital discharge: an SNDS study

Objective: Our aim was to measure the effectiveness of home care pressure ulcer (PU) prevention devices (PUPDs) for at-risk patients after hospital discharge in France.
Method: We conducted a retrospective analysis of PU-associated hospitalisations based on the French medico-administrative database (Système National des Données de Santé, SNDS), which covers the entire French population. All adults >70 years of age, hospitalised from July 1 to December 31 2015, and equipped with a medical bed at home, were included. Follow-up was for a maximum of 18 months. The propensity score matching allowed the comparison of PUPD equipped and non-equipped groups (No-PUPD), considering sociodemographic characteristics and other factors.
Results: The study included 43,078 patients. Of this population, 54% were PUPD patients and 46% No-PUPD. After matching, PUPD patients had significantly fewer PUs than No-PUPD patients (5.5% versus 8.9%; p<0.001). The adoption of PUPD reduced by 39% the risk of PU in hospital. Patients equipped within the first 30 days at home after hospitalisation had fewer PUs than those equipped later (4.8% versus 5.9%). The estimated PUPD use costs represented 1% of total healthcare expenditure per patient during the study period.
Conclusion: The study results demonstrated the effectiveness of the adoption of mattress toppers or prevention mattresses in reducing PU occurrence in patients aged >70 years of age. A short delay in PUPD delivery appeared to have a real impact in the medical setting. Future research on a larger population might provide more evidence on the appropriate support and timeframe to choose based on risk assessment.
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epidemiology • mattress • pressure injury • pressure ulcer • primary prevention • SNDS • wound • wound care • wound dressing • wound healing

Pressure ulcers (PUs) are debilitating hard-to-heal wounds commonly occurring in patients confined to bed or who sit in a chair or wheelchair for prolonged periods of time. One-in-ten adults hospitalised can be affected by PUs, mostly at the level of sacrum, heels and hip,[1,2] and one-in-three patients with spinal cord injury.[3] Although PU is preventable through early risk assessment and appropriate pressure-reducing strategies, these injuries contribute to prolonged hospitalisation and worse medical outcomes. Heavy consequences in terms of cost of care and emotional, physical and social quality of life (QoL) involve not only the patient, but also family and health professionals.[4–6]

According to the French health insurance system, PU is a major public health problem in the country, with room for improvement in management, particularly in terms of healing times, prevalence and recurrence rates.[1] In France, three national surveys, conducted in 1994, 2004 and 2014 by L'Association Prévention, Education, Recherche, Soins, Escarres (PERSE) reported prevalence and incidence of PUs among hospitalised patients.[5] In 2014, the prevalence in France ranged from a minimum of 1.1% (psychiatry service) to 11.8% (recovery, rehabilitation and follow-up service), depending on the typology of the hospital service. The average PU prevalence among hospitalised patients in France in 2014 was 8.1%, compared with 8.9% in 2004 and 8.6% in 1994.[7] According to recent systematic reviews, the prevalence of PUs was estimated to be around 10.8–12% in both hospital and long-term care settings across Europe.[8]

In Africa, PU prevalence and incidence in clinical settings present similar figures to some European countries which have older populations (higher proportion of patients >65 years of age) compared with Africa, indicating that the risk of PU does not fully depend upon the age of the population.[8,9] Care setting-specific studies have shown even higher prevalence rates for both hospital and long-term care settings across European countries, with the highest PU prevalence reported from the Netherlands (27.2%).[9]

Based on the last Global Burden of Disease (GBD) study, the global prevalence rate of PU increases with age, and countries like Malaysia, Saudi Arabia and Thailand experienced the most significant increases in age-standardised prevalence rates at the national level.[10]

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Some extrapolations suggest an annual prevalence of 300,000 PUs for the entire population of France; the incidence varies according to each risk factor evaluated and each study. According to the French National Authority for Health (Haute Autorité de Santé, HAS), the prevalence of PUs in home care was estimated to be between 70,000–112,000 cases per year, with an estimated 470,000–1.22 million patients at risk.[11] According to an analysis published in 2014, a total of 52,600 patients per year were likely to be discharged from hospital with a PU, or to be high-risk patients for developing PUs after hospitalisation due to their age or pathology (Système National d'Information Interrégimes de l'Assurance Maladie (SNIIRAM) 2011 database).[12] Of these, 64% (33,800 patients) who received outpatient treatment for PUs were hospitalised within a period of <1 month before the start of PU treatment and 36% of patients (18,800 patients) were hospitalised between 1–3 months before their first outpatient PU treatment.

PUs particularly affect bedbound patients (3% of those hospitalised) especially the older ones (22% of those hospitalised over 65 years of age). Patients with PUs are on average 8.5 years older than all hospitalised patients (79.9±12.4 versus 71.4±12.9 years of age; p<0.0001).[5] Patients with heart or respiratory failure, or type 2 diabetes, are also at higher risk of PU, as reported in community settings, hospitals and nursing facilities.[13] Current epidemiological studies in home healthcare settings are insufficient and provide only low-level evidence of prevalence and incidence of this common phenomenon.

PU aetiology has been extensively studied. Laboratory evidence supports several aetiological pathways, including ischaemia from capillary closure, reperfusion injury and tissue deformation that trigger and/or promote inflammatory and ischaemic damage, leading to cell death and tissue necrosis.[14] Depending on exposure time of mechanical loads, skin vulnerability and microclimate (temperature, humidity and airflow), nutritional and hydration status, a PU can take a longer time to heal. Low body weight (undernutrition, malnutrition, weight loss, oral eating problems), high body weight, and disproportionate weight distribution for prolonged periods of inactivity/immobility contribute to the likelihood of having PUs.[15–17]

Prevention depends on several factors and is represented by multidisciplinary approaches throughout the patient's life.[18–20] The prevention strategy covers patient risk assessment, evaluating the level of mobility, hygiene of life, good nutrition and fluid intake, smoking and stress.[20] Mobilisation and frequent repositioning, mobility aids, skin care, including management of incontinence, medical devices associated with medical nutrition, and also medical devices such as support surfaces (mattresses and cushions) which help prevent and relieve PUs, represent relevant preventive strategies for PU. The different types of PU prevention aids are categorised and indicated according to the risk of developing a PU (bed rest, ability to move independently, vascular, and neurological medical history). Depending on the risk and the corresponding category, the indication of the prevention material will be different (waffle mattress, viscoelastic foam, air mattress). Good practice guidelines show evidence of the superiority of a mattress with technical specifications for PU prevention compared with a simple (non-therapeutic) mattress but not between them (static, dynamic alternating pressure supports).[21] The HAS recognises the therapeutic value of certain mattresses in helping to prevent PUs, and their public health value, considering the risk of hospitalisation/re-hospitalisation, disability appearance and QoL degradation engendered by the occurrence of a PU.[22] These mattresses are registered on the list of products and services refundable by the health insurance scheme (French health insurance system) and can be made available for home care by a physician prescription before leaving the institution or by the referring physician.

The French Ministry of Solidarity and Health reported health inequalities among regions (Rapport-ESPF-2017),[23] and it has been observed empirically that for patients with similar pathologies and risk factors, the prescription of a PU prevention device (PUPD) varies.[24] As in other countries, beside risk assessment,

Fig 1. Flow diagram

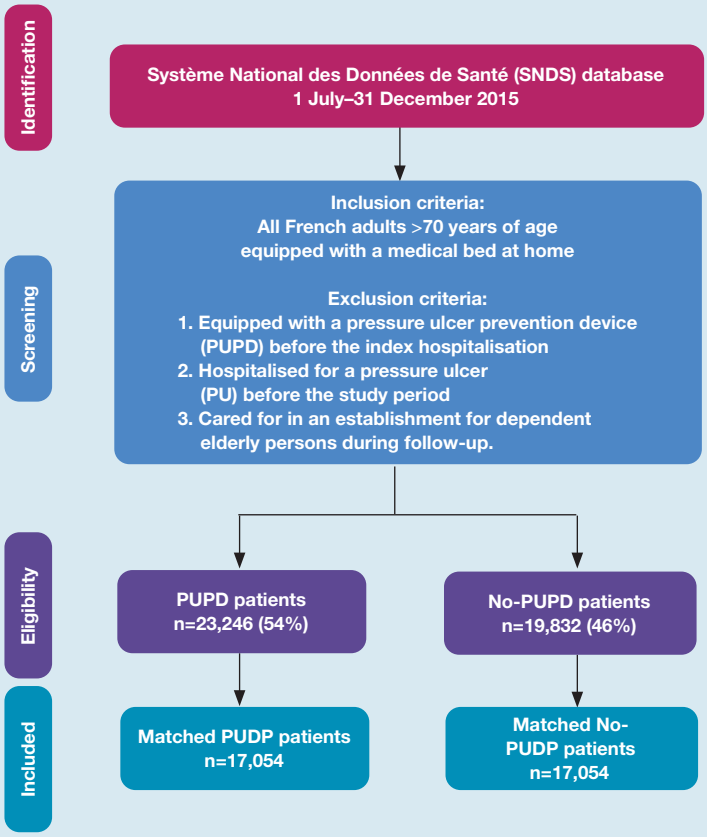


Table 1. Patients' matching variables

Variables considered	
Sociodemographic characteristics	Age Sex
Hospitalisation	Length of stay Severity level 1 Severity level 2 Severity level 3 Severity level 4
Study follow-up	Length
Comorbidities	Cardio- and neurovascular diseases Diabetes Cancer Psychiatric diseases Neurological or degenerative diseases Chronic respiratory diseases (excluding cystic fibrosis) Inflammatory or rare diseases or HIV or AIDS Chronic end-stage renal disease Liver or pancreas diseases Other long-term conditions (including LTD 31-Other, LTD 32-Polypathology)
Treatments (comorbidities)	Vascular risk treatments Psychotropic treatments (excluding pathologies)
Medical devices	Medical device associated with incontinence* Medical device for nutrition* At least one medical mobility assistance device* Walker Patient lift Wheelchair Cane Shell chair

Severity of hospitalisations was defined through the third level of the DRG classification associated with the hospitalisation.[30]

* The definition of the medical devices associated with each of the factors is available from the author on request

clinical practice has historically concentrated on PU treatment in France, in line with health economic policies related to hospitals.[6,25] The need for evidence-based effectiveness of preventive practices, including PUPD, on home healthcare management quality in patients at risk and with regard to the costs, remains unfulfilled.

The main objectives of the study were:

- To determine the impact of PUPDs on PU occurrence among adults >70 years old receiving home healthcare after hospital discharge
- To estimate the cost-effectiveness of the analysed PU preventive strategy (mattress toppers or prevention mattresses belonging to different technical categories) associated with home healthcare management.

Method

Data source

This study was based on data from the SNIIRAM (National Health insurance inter-scheme information system database) and the Programme de Médicalisation des Systèmes d'Information (PMSI) (National hospital discharge database), both included in the Système National des Données de Santé (SNDS) (National Heath data system), which covers the entire French population.[26,27]

The SNDS provides pseudonymous, comprehensive and individualised data through a unique personal identification number concerning:

- Demographic characteristics of patients (date of birth, sex, town of residence, supplementary universal health coverage rights, attribution of long-term chronic diseases, date of death)
- All reimbursed outpatient healthcare use, such as: consultations with healthcare professionals; drug dispensation according to presentation identification codes (CIP) and/or anatomical, therapeutic and chemical classification (ATC); medical devices according to the list of reimbursable services and products (LPPR); medical interventions according to the Common Classification of Medical Acts (CCAM) nomenclature; paramedical interventions; technical and biological procedures according to the Nomenclature of Medical Biology Acts (NABM)
- Inpatient data from public and private healthcare institutions stored in the PMSI, including information on healthcare institution type, admission, duration, discharge, ICD-10 codes for diagnoses (main diagnosis (DP), related diagnosis (DR) or associated diagnosis (DAS)), medical procedures, ambulatory care and hospitalisation expenditure, defined according to diagnosis-related group (DRG).

Ethical approval

In accordance with French regulations, the study protocol was approved by the Ethics and Scientific Committee for Health Research, Studies and Evaluations (CEREES) and by the French data privacy committee (Commission Nationale de l'Informatique et des Libertés (CNIL)). In the study, personal data processing is intended for a research project not involving human subjects.[28]

Study design

This national epidemiological retrospective study was conducted using the French SNDS database. The study report was completed in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[29]

Study period

The study included patients hospitalised between 1 July and 31 December 2015, for more than 24 hours. Patients were followed until 31 December 2016. The first hospitalisation observed during the study period was considered the index hospitalisation for each patient. The severity of the index hospitalisation was determined by four subclasses from 1–4 indicating, respectively, minor, moderate, major or extreme severity of hospitalisation (further details available from author on request).[30] Patients classified as major and extreme

severity of hospitalisation, subclasses 3 and 4, were analysed together. A 6-month historical period before the first hospitalisation (study inclusion date) was evaluated.

Population

The study encompassed all French adults >70 years of age who were equipped with a medical bed (identified in the LPPR list;[31] further details available from author on request) at home after hospital discharge.

Patients were excluded if they were:

- Equipped with a PUPD before the index hospitalisation
- Hospitalised for a PU before the study period
- Cared for in a nursing home during follow-up care after hospital discharge.

Patients who were prescribed and used a PUPD during follow-up were included in the 'PUPD group'. Patients not equipped with a PUPD during follow-up were included in the 'No-PUPD group'. The PUPDs considered in the study were mattress toppers or prevention mattresses (further details available from author on request) belonging to different technical categories: waffle-type foam, foam with removable modules, viscoelastic foam, static air, and motorised air in alternating mode.[32]

Evaluation criteria and risk factors for PUs

The main evaluation standard was the occurrence of a PU diagnosed during the follow-up period to the hospitalisation and identified according to the algorithm published by the Direction de la Recherche, des Études de l'Évaluation et des Statistiques (DREES) (Directorate for Research, Studies, Evaluation and Statistics) in the framework of Patient Safety Indicators (PSI).[32]

the historical and the follow-up periods. Comorbidities, including those associated as internal risk factors, including incontinence, malnutrition and restricted mobility, in the pathogenesis of PUs, were identified during the historical period according to algorithms used in the mapping published by the National Health Insurance Fund CNAM (Caisse Nationale de l'Assurance Maladie).[33] Pathologies, health conditions and treatments considered during the historical period before hospitalisation were cardio-neurovascular diseases, diabetes, cancers, psychiatric diseases, patients under psychotropic treatment, neurological or neurodegenerative diseases, chronic respiratory diseases (excluding cystic fibrosis), inflammatory or rare diseases or human immunodeficiency virus (HIV) or AIDS, chronic end-stage renal failure, liver and pancreatic diseases, and other long-term illnesses. Other risk factors for PUs, incontinence, malnutrition (undernutrition) and immobility, were identified by the medical devices associated with each condition.[30,32,34]

Table 2. Patients' baseline: demographic characteristics and comorbidities

	Matched population		
	PUPD group	No-PUPD group	p
	n=17,054	n=17,054	
Age, years, mean±SD (min–max)	83.9±6.9 (70–107)	83.9±6.9 (70–107)	NS
Female, %	60.5	61.0	NS
HS level 1, n (%)	2986 (17.5)	2988 (17.5)	NS
HS level 2, n (%)	5189 (30.4)	5200 (30.5)	
HS level 3 and 4 combined, n (%)	7776 (45.6)	7752 (45.5)	
Other HS levels ('short stay hospitalisation', 'hospitalisation not concerned by severity level' or 'hospitalisition with death'), n (%)	1102 (6.5)	1113 (6.5)	
Cardio- and neurovascular diseases, n (%)	7713 (45.2)	7723 (45.3)	NS
Vascular risk treatments (excluding pathologies), n (%)	3236 (19.0)	3241 (19.0)	NS
Diabetes, n (%)	3262 (19.1%)	3276 (19.2%)	NS
Cancer, n (%)	3207 (18.8)	3187 (18.7)	NS
Psychiatric diseases, n (%)	1784 (10.5)	1806 (10.6)	NS
Psychotropic treatments, n (%)	4744 (27.8)	4849 (28.4)	NS
Neurological or degenerative seases, n (%)	3724 (21.8)	3768 (22.1)	NS
Chronic respiratory diseases (excluding cystic fibrosis), n (%)	2581 (15.1)	2573 (15.1)	NS
Inflammatory or rare diseases or HIV or AIDS), n (%)	615 (3.6)	651 (3.8)	NS
Chronic end-stage renal disease, n (%)	90 (0.5)	87 (0.5)	NS
Liver or pancreas diseases, n (%)	455 (2.7)	458 (2.7)	NS
Other long-term conditions (including LTD 31-Other, LTD 32-Polypathology), n (%)	1734 (10.2)	1770 (10.4)	NS

HS—hospitalisation severity (level 1 least severe, level 4 most severe); max—maximum; min—minimum; NS–not significant; SD—standard deviation

Severity of hospitalisation was defined according to the third level of the DRG classification associated with the hospitalization.[30]

A patient may have one or more comorbidities.[33]

Statistical analysis

Descriptive analysis

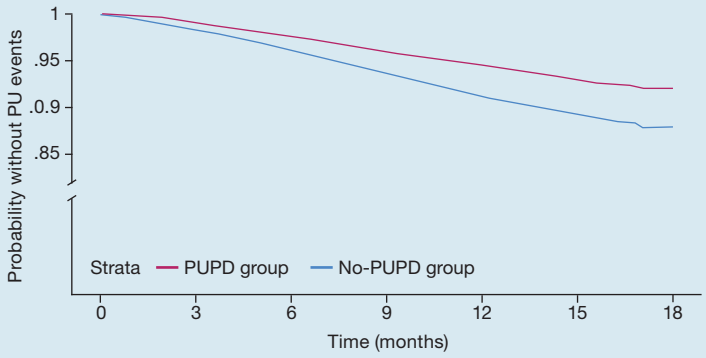
Patient characteristics, including the use of medical devices related to incontinence, malnutrition and immobility assistance were described. Qualitative variables were described by the number and frequency for each modality and quantitative variables by the mean, median, minimum/maximum values, quartiles and standard deviation.

Comparative analysis

Matching: To demonstrate the occurrence of PUs between two comparable groups, a 1:1 non-discounted matching between patients was performed using the propensity score method. As reported in Table 1, this matching considered:

- The sociodemographic characteristics at the time of

Fig 2. Kaplan–Meier probability without pressure ulcer (PU) events curve. Comparison of PU occurrence over time between PUPD (PU prevention device) and No-PUPD groups



Time (months)	0	3	6	9	12	15	18
Patients at risk							
PUPD group	17054	15254	13848	12601	11210	4258	4227
No-PUPD group	17054	14949	13824	12689	11316	4472	4434
PU events							
PUPD group	0	128	359	594	787	907	938
No-PUPD group	0	242	602	971	1305	1483	1521

the index hospitalisation (age, sex, comorbidities)

- The characteristics of the index hospitalisation (duration and severity)

The risk factors likely to influence the occurrence of PUs (incontinence, malnutrition, restricted mobility)

- The duration of follow-up until the last care identified in the database or death.

The two groups were compared by the Student t-test (quantitative variables) and Chi-squared (qualitative variables). All tests performed were two-sided and considered significant at p=0.05.

Severity of hospitalisations was defined through the third level of the DRG classification associated with the index hospitalisation.[30] The delay of PUPD prescription and delivery was analysed only in the propensity-score matched population.

Survival analysis

Rates for incidence (risk) of PU over time were examined using the Kaplan–Meier method. The comparison between the two groups of interest was performed with the log-rank test and 95% confidence interval (CI). The hazard ratio (HR) was estimated with the Cox method.

Economic evaluation

The economic evaluation was performed considering the expenditures reimbursed by the French health system and the French tariffs reported in SNDS.

Analyses

All analyses were performed with SAS Enterprise guide software, version 4.3 (SAS, US) on total population and unmatched or matched subgroups (PUPD and No-PUPD groups).

Results

Patient characteristics

A total of 43,078 PU-associated hospitalisations were identified following the described inclusion and exclusion criteria over the study period (Fig 1). These patients were allocated to the PUPD or No-PUPD groups (54% and 46%, respectively) whether or not they had a PUPD (mattress toppers or prevention mattresses). In the unmatched population the patients' age was a mean of 83.6±6.8 and 84.3±6.9 years in the PUPD and No-PUPD groups, respectively, with a predominance of women (59.4% and 61.6%, PUPD and No-PUPD groups, respectively) (further details available from author on request).

Matching variables are listed in Table 1. The current study analysed two groups of patients, for whom characteristics with respect to all matching variables are shown in Table 2.

The matched groups were comparable in terms of age, sex and hospitalisation severity, with most of the patients at HS levels 2 and 3. Regarding comorbidities, identified by the French Health Insurance,[33] patients had a mean of two comorbidities in each group with a comparable distribution (Table 2).

Other risk factors, such as incontinence, malnutrition, and restricted mobility, were identified through the delivery of medical devices and/or specific equipment associated with these conditions and prescribed to the patient during the study period. The matched groups were comparable in terms of incontinence, malnutrition and restricted mobility medical devices, except for one device associated with restricted mobility, the walker (Table 3). Of note, before matching, patients in the PUPD group were the more equipped in relation to

Table 3. Patients' baseline: medical devices associated with potential PU risk factors

	Matched population		
	PUPD group	No-PUPD group	p
	n=17,054	n=17,054	
Medical device associated with incontinence*, n (%)	2103 (12.3)	2058 (12.1)	NS
Medical device for nutrition*, n (%)	8205 (48.1)	8062 (47.3)	NS
At least one medical mobility assistance device*, n (%)	10,300 (60.0)	9799 (57.0)	<0.001
Walker, n (%)	5501 (32.3)	5271 (30.9)	0.004
Patient lift, n (%)	1445 (8.5)	1365 (8.0)	NS
Wheelchair, n (%)	3282 (19.2)	3188 (18.7)	NS
Cane, n (%)	2004 (11.8)	1909 (11.2)	NS
Shell chair, n (%)	3241 (19.0)	3235 (19.0)	NS

NS—not significant; PUPD—pressure ulcer prevention device

The numbers for the different mobility assistance devices cannot be added together because a patient may have one or more types of medical device

* The definition of the medical devices associated with each of the factors is available from the authors on request

incontinence (+2.6%), malnutrition (+8.15%) and restricted mobility (+11.7%) versus the No-PUPD group (further details available from author on request).

The occurrence of PUs

To analyse the efficacy of the preventive device strategy the number of PU events was evaluated over the 18 month follow-up (Table 4; further details available from author on request). Patients in the PUPD group had significantly fewer events than patients in the No-PUPD group (5.5% and 8.9%, respectively; p<0.0001). A similar trend was observed before matching (further details available from author on request).

The risk for the occurrence of PUs during the study period was estimated using the Kaplan–Meier diagram (Fig 2). These curves show that the risk of developing PU was significantly reduced by 39% (HR: 0.61; 95% CI: 0.57–0.67; p<0.0001) in the PUPD group. The curves started to show a significant vertical gap at month 3, indicating a greater fraction of events in the No-PUPD group, as shown in Fig 2 (further details available from author on request).

In an additional analysis, PU occurrence was evaluated by subgroups of patients defined by the hospitalisation severity index (Fig 3). For each level of HS, the PUPD group had a significantly reduced number of events (HS level 1; p<0.0001, HS level 2; p<0.0001, HS level>2; p<0.0001).

Delay in PU preventive device delivery

Among patients equipped with a PUPD, 66% (n=11,354) were delivered >30 days after the index hospitalisation. The analysis revealed that patients equipped within the first 30 days of hospitalisation had a lower frequency of PU development compared to patients equipped later (4.8% vs. 5.9%) (Table 5). A similar trend was observed before matching (further details available from author on request).

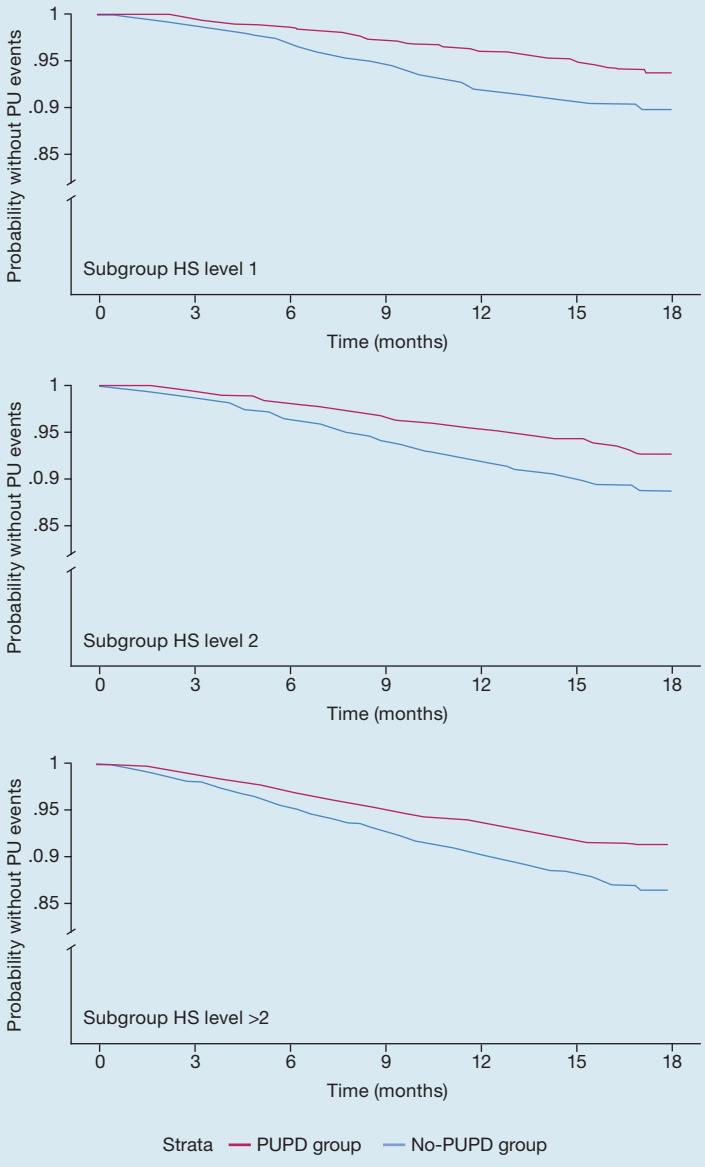
Cost of patient management

During the study period, the analysis of the cost for PUPD use equated to 4.7 million euros, which corresponds to 1% of total healthcare expenditure estimation (hospital care, outpatient care, including treatments, medical devices for individual use, consultations, technical and biological procedures). The costs related to hospitalisation for PU occurrence over 18 months were estimated at 5.9 million euros (2%) for patients in the PUPD group and 10.8 million euros (4%) for patients in the No-PUPD group, confirming that this preventive strategy is cost saving.

Discussion

This national retrospective study aimed to understand the effectiveness of PUPDs to reduce PU occurrence in adults >70 years old hospitalised and followed over an 18-month period (2015–2016). The study was conducted on SNDS data on patients hospitalised for more than 24 hours between 1 July 2015 and 31 December 2016.

Fig 3. Subgroups hospitalisation severity (HS) level analysis. Kaplan–Meier probability without pressure ulcer (PU) events curve. Comparison of PU occurrence over time between pressure ulcer prevention device (PUPD) and No-PUPD groups



The primary outcome is the analysis of PU occurrence over the 18-month follow-up. A significantly lower rate of PUs was observed in the PUPD group (5.5% vs. 8.9% in the matched No-PUPD group), clearly proving the effectiveness of this preventive intervention in the real-world medical setting. These occurrence percentages are slightly lower than the average reported in international studies[8–10] because the PU diagnosis identified in the SNDS database excludes PUs below stage 2, which do not require hospitalisation. However, PU prevalence in France is comparable to our findings,[7] and a recent survey conducted in the Ile de France (IDF), despite the

Table 4. Occurrence of PU events

	Matched population		
	PUPD group	No-PUPD group	p
	n=17,054	n=17,054	(Chi-squared)
Occurrence of PU in the hospital	938 (5.5%)	1521 (8.9%)	< 0.001

PU—pressure ulcer; PUPD—pressure ulcer prevention device

Table 5. Time of delay in PUPD delivery in patients after matching

	PUPD group		
	Delay ≤30 days	Delay >30 days	Total
	n= 5700	n=11,354	n=17,054
Occurrence of PU in the hospital	271 (4.8%)	667 (5.9%)	938 (5.5%)

PU—pressure ulcer; PUPD—pressure ulcer prevention device

difficult health situation due to COVID-19, highlighted an overall increase in PU risk and severity compared to previously reported figures. Moreover, the prevalence of PUs in palliative care in France varies between 11.7–12.4%, which is less than in the national intensive care unit survey conducted in 2018, with almost 20%. In this survey, the palliative care population seems particularly fragile and more at risk of PUs. Of these 633 patients, 54.4% were women and had a median age of 73 years (18–97 years); half had only one PU and 10% had four or more. Although concerning another type of at-risk population, these results support our findings about the importance of the actualisation of good clinical practice in hospitalised patients, particularly when older. These reports focus attention on the need for PU preventive strategy implementation and confirm the reliability of our results, despite the difference in study design. In addition, the specific age population followed in our study fully reflected the average age of PU patients reported in the 2014 PERSE survey.[5] This means that our analysis confirms that this specific age group needs more attention as well as additional prevention and management measures.

Access to the SNDS data allowed our analysis to confirm the importance of PUPD as one of the best PU preventive practices, as recommended.[35] When the risk of developing PU was evaluated over time, the risk of PU occurrence was significantly reduced by 39% ($p<0.0001$) in the PUPD group. In addition, our results demonstrated the key role of a quality medical prescription, upon hospital discharge or by inpatient-attending physician, within a brief period. Patients equipped with a PUPD within the first 30 days after index hospitalisation had a lower PU occurrence compared with patients for whom the PUPD was delivered beyond 30 days (4.8% vs. 5.9%). Of note, our analysis revealed that the PUPD group had a better level of equipment in terms of mobility aids, even after matching (Table 3). Although it is important to consider the effect of the large sample size in the probability of finding significance, the discrepancy with the No-PUPD group suggests that these subjects have received an overall higher level of care, which potentially improved their health outcome and QoL.

The findings are consistent with international clinical practice guidelines which recommend the prescription of a medical bed for people with temporary or permanent autonomy loss in association with PU risk assessment and, in the case of reduced mobility or immobility, providing prescription of PUPD.

The analysis, before matching, showed that 46% of patients equipped with a medical bed and having comorbidities and potential PU risk factors (incontinence, malnutrition, restricted mobility) were not equipped with a PUPD. In these patients, PU frequency was higher than in PUPD patients and it increased over time. It is tempting to hypothesise that the hospitalisation for the patients who were not equipped may be defined by longer durations, since No-PUPD patients had a higher number of PU events, and PU occurrence increases hospitalisation length by about 9.8 (±0.14) days, as reported in 2016 in France.[36] Prolonged hospitalisations have consequences not only on patient psychology and family care management, but also on the French healthcare system, considering that the average length of stay for full hospitalisation in medicine, surgery and obstetrics (MCO) is 5.5 days.[37] Moreover, it is important to note that, once the analysis of PU occurrence was implemented in subgroups by hospitalisation severity level, whatever the health status of the patient, the adoption of PU preventive devices proved to be effective. Patients equipped with PUPD, even when hospitalisation severity level was major and extremely severe, showed significantly lower PU occurrence than No-PUPD patients. This observation highlights the crucial role of healthcare professionals in carefully evaluating PU risks of patients, and adopting preventive measures in a timely manner independent of hospitalisation severity rating.

Once the ischaemic process that causes cell death and tissue damage has begun, PUPDs have limited effectiveness. In our analysis, two-thirds (66.6%) of the PUPD patients received the preventive device after a delay of >30 days. This delay necessarily has an impact on PU frequency, PU severity and on the effectiveness of these devices. The absence of PUPD adoption in a population at risk, or a delay in issuing the devices, might be related to a lack of knowledge or training in the device therapeutic applications, particularly among private practitioners, in the authors' opinion (unpublished). Moreover, the accessibility of these devices in community settings is less easy than in hospitals. Advice and support must be given to practitioners, professional caregivers and patients to facilitate the appropriate prevention, management and intervention plans. Recent Cochrane reviews show low-to-moderate certainty evidence in the effectiveness of different mattress technologies to prevent PUs.[35,38] The

difference in PU incidence between using active water surfaces, reactive fibre surfaces, reactive air surfaces versus foam surfaces remains uncertain.[35] What is certain, and has been for a while, is the relationship between PU complications and the increased mortality risk of older patients,[39–41] but also that preventive strategies are globally effective in reducing PU incidence.[10,19] The US National Pressure Injury Advisory Panel (NPIAP) reports that the 30-day readmission rate for patients with PU is up to 22.6%, and that each year 60,000 patients die as a direct result of complications from hospital-acquired PU.[7,42] The recommended prevention strategies for any patient at risk of developing a PU have been updated and disseminated in the National Pressure Ulcer Advisory Panel (NPUAP)/ European Pressure Ulcer Advisory Panel (EPUAP)/Pan Pacific Pressure Injury Alliance (PPPIA) 2019 Guidelines for prevention and treatment of pressure ulcers.[43] Strategies include risk assessment, nutritional assessment and supplementation, repositioning and mobilisation, use of appropriate support surfaces, and skin assessment and care.

An additional outcome of the current study was related to healthcare costs. The measurement of the economic impact showed that the costs of PUPDs had a low impact on the total costs of care, representing 1% of the total. Nevertheless, all healthcare systems around the world recognise the benefit of PU prevention for patients. However, whereas the prevalence of PUs has remained largely unchanged over the past 20 years, the associated care costs continue to rise. One of the critical drivers of health expenditure growth is population ageing, and recent studies underline how the prevalence of multimorbidity increases with age, being higher among females. Our study underscores the need of preventive interventions for PU in hospitals, analysing a population of older adults, with a prevalence of females, and a known number of comorbidities. Indeed, the occurrence of PU was significantly reduced in patients equipped with PUPD in a timely manner. Moreover, for PUPD patients the average costs of hospitalisation due to PUs was reduced to half compared with No-PUPD patients.

The consequences of PUs in terms of patient safety (delaying patients' return to full functioning, severe pain, antibiotic and surgical treatments, also decreasing emotional, mental, and social health) and costs for health systems are significant. While prophylactic and therapeutic care are relatively harmonised between countries by following national and international guidelines for patient management, the costs of direct and indirect care vary between countries. Recent literature, including health economic studies from the US, Canada, Western Europe and the UK, showed large variability in the estimation of costs for PU prevention and treatment because of methodological and perspective heterogeneity among studies.[32,34,48–50] The clear consensus is that costs of PUs from societal and healthcare system perspectives are substantial, and that prevention technology would reduce them,[51] consistent with the current study.

Limitations

One strength of this study is the use of the SNDS database, covering around 99% of the French population and allowing long-term follow-up. The patient pathways and associated resource use are based on real-world evidence derived from clinical practice. This study is of large scale, and it inspires public interest. Our results raise awareness on PU frequency in this at-risk population and highlight the urgency of implementing appropriate prevention strategies to reduce healthcare costs in France. Furthermore, the analysis established, for the first time, the effectiveness of a specific preventive intervention (mattress, mattress topper) within hospital settings.

This study has several limitations. First, it is based on administrative reimbursement data, where coding errors might be possible, and collection has no research purpose. Another limitation is the inclusion of patients affected by PUs with a high severity grade defined by PU diagnosis when admitted to the hospital. This is because PUs with a low severity grade are difficult to identify in ambulatory care, particularly using wound dressings as treatment, which are also used for different hard-to-heal wounds. The analysis is limited by the specificity of the study population considered to analyse the impact of PUPD on PU occurrence. Adults >70 years old, with a single full hospitalisation in the second half of 2015, were considered, when equipped with a medical bed for homecare. Moreover, with respect to PU prevention technologies considered for this study (mattress, mattress topper), they were analysed as one entity and without stratifying the analyses by technology. The analysis was limited to a maximum follow-up of 18 months. Hence, the study could not consider the potential impact of PU occurrence beyond the study period. Finally, the information on patient characteristics is insufficient to determine all potential risk factors. Lack of information related to the French and international scale of mobility does not allow determination of patient dependence, especially human dependence (visits by medical nurses, family assistance, etc.).

Conclusion

Our study provides relevant information and evidence for health professionals and healthcare decision-makers. The prevention of PUs in at-risk populations is a public health issue, PUs being common, hard-to-heal and progressive wounds that have a direct impact on patients' QoL and healthcare expenditures. The choice of patient profile at risk of developing PUs by the French authorities and the specificities of preventive measures are largely based on expert advice. Our data provide evidence indicating the effectiveness of PUPD adoption in reducing PU occurrence, and the critical role of a short delay in the device delivery in real-world medical

Reflective questions

- In the context of two groups of patients, equipped or not with pressure ulcer prevention devices (PUPD), with similar demographic characteristics and comorbidity factors, which medical information could guide the prescription of a support surface for pressure ulcer (PU) prevention after hospital discharge?
- Why should a healthcare professional, caring for an at-risk patient at home, recommend the immediate prescription of a support surface for PU prevention by the physician?
- How might it be relevant to carry out a similar study distinguishing reactive and active support surfaces for PU prevention in cases of medical bed use?
- Could a systematic evaluation of the Braden score, in association with clinical assessment, at hospital discharge improve the decision to prescribe a PUPD and contribute to the appropriate support identification?

settings. This study could be further completed by analysis on a larger population using more recent French national data. **JWC**

Data availability

The datasets generated for this study can be found in the SNDS database upon request to the regulatory authorities.

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