Prevalence and impact on quality of life of peripheral neuropathy with or without neuropathic pain in type 1 and type 2 diabetic patients attending hospital outpatients clinics

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Abstract

Aims. – Diabetic polyneuropathy (DPN) without or with neuropathic pain (DPN-P) is one of the most frequent complications of diabetes. To better delineate their respective prevalences, we conducted a cross-sectional study that included 1111 patients (767 type 2 and 344 type 1 diabetic patients) followed up in diabetic outpatients clinics. The association of DPN and DPN-P with other diabetic complications, the impact on quality of life (QoL) and pain management were also investigated.

Methods. – Two validated tools (Neuropen® and the DN4 questionnaire) were used to diagnose the two conditions. Pain intensity was measured using a visual analogue scale, and participants completed the 12-item Short-Form Health Survey to evaluate the physical and mental components of QoL. Univariate and multivariate models were used for the statistical analyses.

Results. – The prevalence of DPN was 43% (95% CI 40.1–45.9), and was higher in type 2 (50.8%) than in type 1 (25.6%) diabetic patients. The prevalence of DPN-P was 14% (95% CI 12.1–16.2) which, again, was higher in type 2 (17.9%) than in type 1 (5.8%) patients. These prevalences both increased with age and diabetes duration. Nephropathy, obesity, low HDL cholesterol and high triglyceride levels were independently associated with DPN and/or DPN-P. Physical and mental components of QoL were significantly altered by DPN-P, but not DPN. Only half of the DPN-P patients were using analgesic treatment, while 28% were using anticonvulsants or antidepressants.

Conclusion. – DPN and DPN-P are frequent complications of diabetes, especially in type 2, and can be identified with inexpensive and easy-to-use screening tools. Despite its profound impact on QoL, DPN-P remains undertreated.

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Keywords: Diabetic peripheral neuropathy; Diabetic peripheral neuropathic pain; Quality of life; DN4; Neuropen®

Résumé

Prévalence et impact sur la qualité de vie de la neuropathie diabétique périphérique avec ou sans douleurs neuropathiques dans une population de patients diabétiques (types 1 et 2) suivis en consultation spécialisée.

Buts. – La neuropathie périphérique diabétique (NPD) accompagnée ou non de douleurs neuropathiques (NPD-D) est une des complications les plus fréquentes du diabète. Afin d’en préciser les prévalences respectives, nous avons mené une étude transversale à partir d’une cohorte de 1111 patients (767 patients diabétiques de type 2 et 344 patients diabétiques de type 1) suivis en consultations spécialisées. L’association entre NPD et NPD-D et les autres complications du diabète, l’impact sur la qualité de vie (QdV) et le traitement médicamenteux furent aussi analysés.

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1. Introduction

Diabetic polyneuropathy (DPN) is one of the most common long-term complications of diabetes, characterized by progressive sensory loss predisposing to neuropathic foot ulceration and associated with premature mortality [1,2]. DPN is associated in some patients with neuropathic pain (DPN-P) that responds poorly to conventional analgesics [2–4]. Despite its clear typical clinical expression (burning pain, electrical shocks associated with paraesthesia/dysaesthesia and/or allodynia), neuropathic pain still goes underdiagnosed [5,6]. A DPN prevalence rate as high as 50% has been reported in the literature [7], but there are considerable differences across studies, which may be due to methodological differences and the lack of consensus on its diagnostic criteria [8]. Data related to the prevalence of DPN-P are even more sparse and variable [6–11]. A significant proportion (10–20%) of type 2 diabetic patients with DPN requires treatment for severe painful symptoms that develop over time [12]. Older age, long diabetes duration and poor glycaemic control are well-established risk factors for DPN and are possibly also associated with DPN-P [13]. Other previously reported coexisting factors are patients’ gender, height, insulin therapy, smoking status, alcohol consumption, high BMI, elevated systolic blood pressure, presence of peripheral vascular disease, retinopathy, nephropathy and hypercholesterolaemia. However, there is no clear consensus as to whether or not they are indeed associated with DPN and/or DPN-P [1,14–17].

Thus, there remains a lack of epidemiological information that is crucial for improving the management of DPN and DPN-P, and for guiding the direction of future research. In particular, identification of the commonly associated patient characteristics and co-morbidities would be of major importance for the initiation of appropriate strategies to prevent neuropathic complications, such as infections and foot ulcers [1,3]. In addition, clearer knowledge of the impact on patients’ quality of life (QoL) is also helpful for delivering the optimal patient care.

For these reasons, this nationwide study was carried out in Belgian diabetes clinics, using inexpensive and easy-to-use screening tools, to estimate the prevalences of DPN and DPN-P, and to determine whether or not it varies according to the type of diabetes (type 1 or 2). Furthermore, the association of DPN and DPN-P with other diabetic complications, and the impact of these conditions on the QoL and current therapeutic management of DPN-P were also investigated.

2. Subjects and methods

2.1. Patients

The patients recruited into our study were those making consecutive visits (the first five consultations every day for 3 consecutive weeks) to 40 outpatients diabetes clinics across Belgium. Study eligibility criteria were: type 1 or type 2 diabetes diagnosed more than 1 year ago; age over 18 years; and their informed consent. There were no exclusion criteria except for non-fulfilment of the study requirements, and the trial was approved by the appropriate ethics committee. A total of 1216 diabetic patients were screened, of which 1111 patients—including 344 type 1 and 767 type 2 diabetic patients—were found to be eligible. A total of 105 patients were excluded from the analysis because of incomplete records or deviation from the inclusion criteria: 42 had secondary diabetes; 29 had diabetes of unknown type; 11 had been diagnosed less than 1 year; six were of unknown age; two were less than 18 years old; six had missing Neuropen® data and nine had an incomplete DN4 questionnaire. The demographic and clinical characteristics of the 1111 diabetic patients are shown in Table 1. On average, type 2 diabetic patients were older and had known diabetes of shorter duration and slightly better glycaemic control. They also had a higher average BMI, more cardiovascular risk factors and more frequent long-term complications (except retinopathy) than type 1 diabetic patients. They also used insulin in more than 70% of cases.

2.2. Methods

Simple handheld screening tools—namely, Neuropen® and the DN4 questionnaire—were used to assess DPN and neuropathic pain, respectively. For this study, DPN-P was defined as the combination of DPN (a positive Neuropen® test) together with pain that had neuropathic characteristics (a positive DN4 score). The Neuropen® (Owen Mumford Ltd, Oxford, UK) is
### Table 1

Study patients’ characteristics.

<table>
<thead>
<tr>
<th></th>
<th>Type 1</th>
<th>Type 2</th>
<th><em>P</em> value</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>n</em> = 1111</td>
<td><em>n</em> = 344 (31%)</td>
<td><em>n</em> = 767 (69%)</td>
<td></td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td>45.9 ± 15</td>
<td>63.6 ± 11</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Gender (% female)</strong></td>
<td>45.8</td>
<td>43.2</td>
<td>0.43</td>
</tr>
<tr>
<td><strong>BMI (kg/m²)</strong></td>
<td>25.4 ± 3.9</td>
<td>30.9 ± 5.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Obesity</strong></td>
<td>11.7</td>
<td>48.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Waist circumference, male (cm)</strong></td>
<td>91.2 ± 11.7</td>
<td>106.4 ± 14.3</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Diabetes duration (years)</strong></td>
<td>16.5 (10–27)</td>
<td>11 (6–18)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>HbA₁c (%)</strong></td>
<td>7.8 ± 1.17</td>
<td>7.58 ± 1.29</td>
<td>0.006</td>
</tr>
<tr>
<td><strong>Insulin use</strong></td>
<td>100</td>
<td>73.7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Nephropathy</strong></td>
<td>17.4</td>
<td>30.4</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Impaired renal function</strong></td>
<td>6.8</td>
<td>20.2</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Retinopathy</strong></td>
<td>33.1</td>
<td>25.2</td>
<td>0.007</td>
</tr>
<tr>
<td><strong>Foot lesions</strong></td>
<td>3.8</td>
<td>6.6</td>
<td>0.07</td>
</tr>
<tr>
<td><strong>Systolic blood pressure (mmHg)</strong></td>
<td>129.1 ± 16.5</td>
<td>137.8 ± 17.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Diastolic blood pressure (mmHg)</strong></td>
<td>75.7 ± 9</td>
<td>77.4 ± 10</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Blood pressure ≥ 130/85 mmHg</strong></td>
<td>68.6</td>
<td>82.8</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Lipid parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total cholesterol (mmol/L)</strong></td>
<td>4.68 ± 0.93</td>
<td>4.56 ± 1.02</td>
<td>0.07</td>
</tr>
<tr>
<td><strong>Total cholesterol ≥ 4.5 mmol/L</strong></td>
<td>54.2</td>
<td>48.1</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>HDL cholesterol (mmol/L)</strong></td>
<td>1.75 ± 0.54</td>
<td>1.35 ± 0.43</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>HDL cholesterol (≤ 1 mmol/L for men, ≤ 1.3 mmol/L for women)</strong></td>
<td>8.4</td>
<td>31.4</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Triglycerides (mmol/L)</strong></td>
<td>1.16 ± 0.72</td>
<td>1.78 ± 1.36</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Triglycerides ≥ 1.7 mmol/L</strong></td>
<td>18.1</td>
<td>39.6</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Data are expressed as means ± SD, medians (5th percentile, 95th percentile) or percentages.

- **Obesity**: BMI ≥ 30 kg/m².
- **Nephropathy**: Microalbuminuria and/or proteinuria.
- **Creatinine clearance < 60 mL/min**.
- **Retinopathy**: Background or proliferative retinopathy.
- **Foot lesions**: Ulcer, Charcot foot, amputation.

A clinical device that assesses pain/sharpness sensation through the calibrated Neurotip® at one end of the ‘pen’ (via a superficial pain-sensation test), and touch/pressure perception via a 10 g monofilament at the other end (monofilament test). The device is now considered sensitive enough to assess neurological function and offers an inexpensive alternative screening method for identifying patients with moderate-to-severe neuropathy [18].

In the present study, the monofilament end of the pen was applied for 2 seconds to the plantar face of the first, third, fourth and fifth metatarsal heads, and the Neurotip® end to the plantar face of the first toe. Both feet of each patient were tested. The result was considered positive if patients did not feel the stimulus on more than one of the tested sites in the monofilament test or if the pinprick stimulus was not felt in at least one foot.

The DN4 questionnaire is a clinician-administered questionnaire to identify neuropathic pain characteristics that was recently developed and validated by a group of French experts [19]. The questionnaire consists of 10 items, seven of which are based on the patient’s anamnesis of the pain characteristics (pain descriptors) and the presence of paraesthesia/dysesthesia in the same body area. The remaining three items are related to the presence of hypoesthesia (touch and/or pinprick) in the painful area and the presence of brush-evoked allodynia (pain induced by light brushing of the skin). A score of 1 is given for each positive item and the total score is calculated as the sum of all 10 items. The cut-off score of 4/10 represents the highest percentage of correctly diagnosed patients (86.0%), with a sensitivity of 82.9% and a specificity of 89.9% [19]. Specific training was given to all study investigators prior to the beginning of the study to ensure that the assessment of DPN and DPN-P was perfectly standardized.

#### 2.3. Study design

Each patient’s demographics, diabetes characteristics and complications, cardiovascular risk factors and pain treatments were recorded through standardized questionnaires. Patients were then invited to report any pain they were suffering in their feet and/or legs and to rate its mean intensity over the previous week on a visual analogue scale (VAS) that was graded from ‘no pain’ (0 cm) to ‘worst possible pain’ (100 cm). Patients with pain answered the DN4 questionnaire (as described above). Participants were also asked to complete the Medical Outcomes Study 12-item Short-Form Health Survey (SF-12) questionnaire, which has been found to be reliable and valid in diabetic patients for evaluation of the physical and mental components of QoL [20].
Table 2
Multivariate associations between diabetic polyneuropathy (DPN), without and with neuropathic pain (DPN-P) and patients’ characteristics.

<table>
<thead>
<tr>
<th></th>
<th>DPN</th>
<th>DPN-P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR (95% CI)</td>
<td>P valuea</td>
</tr>
<tr>
<td>Gender (female)</td>
<td>0.7 (0.52–0.95)</td>
<td>0.02</td>
</tr>
<tr>
<td>Age (per 10 years)</td>
<td>1.56 (1.36–1.8)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Diabetes type (type 2)</td>
<td>1.65 (1.04–2.6)</td>
<td>0.03</td>
</tr>
<tr>
<td>Diabetes duration (per 5 years)</td>
<td>1.16 (1.07–1.26)</td>
<td>0.0006</td>
</tr>
<tr>
<td>Current smoker</td>
<td>1.37 (0.92–2.05)</td>
<td>0.12</td>
</tr>
<tr>
<td>Obesity</td>
<td>1.26 (0.91–1.73)</td>
<td>0.17</td>
</tr>
<tr>
<td>Blood pressure ≥130/85 mmHg</td>
<td>1.3 (0.89–1.89)</td>
<td>0.17</td>
</tr>
<tr>
<td>Total cholesterol ≥4.5 mmol/L</td>
<td>1 (0.74–1.37)</td>
<td>0.99</td>
</tr>
<tr>
<td>HDL cholesterol (≤1 mmol/L for men, ≤1.3 mmol/L for women)</td>
<td>2.12 (1.47–3.04)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Triglycerides ≥1.7 mmol/L</td>
<td>1.08 (1.08–1.52)</td>
<td>0.65</td>
</tr>
<tr>
<td>Nephropathy</td>
<td>1.25 (0.9–1.75)</td>
<td>0.19</td>
</tr>
<tr>
<td>Retinopathy</td>
<td>1.38 (0.97–1.95)</td>
<td>0.07</td>
</tr>
</tbody>
</table>

a Multivariately adjusted odds ratios (OR) and significance.

2.4. Statistical analysis

Univariate and multivariate models were used to analyze the patients’ data. Differences in patients’ characteristics between type 1 and type 2 diabetics were compared using t and Fisher’s exact tests. Associations between DPN and DPN-P and other clinical characteristics or diabetic complications were studied through multiple logistic-regression analyses. The power and statistical significance of these associations are expressed as odds ratios (OR) with their accompanying 95% confidence intervals (CI). Multivariate analyses of QoL scores were carried out using analysis of covariance. A level of α = 0.05 was adopted to indicate statistical significance. All analyses were carried out using SAS software (Release 9.1, Cary, North Carolina, USA). Where appropriate, data are presented as means ± SD.

3. Results

3.1. Prevalence of DPN and DPN-P

A total of 478 patients had a positive Neuropen® test representing an overall DPN prevalence of 43.0% (95% CI 40.1–45.9), with a significantly higher prevalence in type 2 than in type 1 diabetic patients (50.8% vs 25.6%; P = 0.0007, after adjustment for age and duration of diabetes). Also, the prevalence of DPN significantly increased with age and duration of diabetes (P = 0.0001) (Fig. 1A; Table 2).

In 157 (32.8%) patients, DPN was associated with pain that had neuropathic characteristics. Thus, the overall prevalence of DPN-P was 14.1% (95% CI 12.1–16.2), with a significantly higher prevalence in type 2 than in type 1 diabetic patients (17.9% vs 5.8%; P = 0.002, after adjustment for age and diabetes duration). The mean pain intensity, as measured by the VAS score, was 47.6 ± 26, and 61.0% of the patients had pain of at least moderate intensity (VAS ≥ 4). In contrast, the mean VAS score was only 13.5 ± 21 in the 321 DPN patients without pain. The prevalence of DPN-P significantly increased with age (P < 0.0001) and duration of diabetes (P = 0.004) (Fig. 1B; Table 2).
3.3. Impact of DPN and DPN-P on patients’ QoL

Multivariate analyses of QoL scores revealed that DPN-P independently affected both the physical and mental QoL, even after adjusting for pain intensity. In addition, changes in physical QoL were associated with age and BMI, while a poorer mental QoL was associated with female gender, smoking, BMI and diabetes duration. DPN alone had no statistically significant effect on either physical or mental QoL scores (Table 3).

3.4. Current analgesic treatments

Half of our study DPN-P patients (56.7%) were being treated for painful neuropathic symptoms. These patients were taking aspirin (3.2%), paracetamol (29.9%), non-steroidal anti-inflammatory agents (12.7%), weak opioids (15.9%) and opioids (1.3%). Only 28.0% were prescribed anticonvulsants (21.0%) or antidepressants (8.3%).

4. Discussion

The medical and psychological consequences of neural damage in diabetes are commonly seen and result in a high patient morbidity and loss of QoL [1–3, 12–15, 21]. The present nationwide epidemiological survey, one of the largest specifically devoted to DPN and DPN-P, confirms their high prevalence and impact on health-related QoL, especially in patients with type 2 diabetes.

One advantage of the present study was the large size of our patient cohort. In 2006 in Belgium, 86,167 type 1 or 2 diabetic patients were treated with at least two injections of insulin. A survey (the IKED project) carried out in 9146 patients showed a distribution of 25.7, 70 and 4.3% for type 1, type 2 and secondary forms of diabetes, respectively. Those proportions, similar to the findings reported here, confirm the representativeness of our patient sample.

Another strength of the present study was the use of validated clinical screening tools (the Neuropen® device and DN4 questionnaire). Although these may appear crude at first sight, both are well validated and share the advantage of being specific, sensitive, inexpensive and, most important of all, easy to use. This means that they can be applied on a daily basis after only a short period of training and do not require specific expertise. Given this basis, DPN and DPN-P should no longer be viewed as ‘the forgotten complication’, as was recently stated by the American Diabetes Association [1].
It is also worthwhile noting that our cohort of patients was selected from outpatients clinics, which usually recruit more severe cases that do not reflect the population of diabetic patients usually seen, for instance, by primary-care practitioners. This may explain the large proportion of type 2 diabetic patients in our survey being treated with insulin. For this reason, further investigations are currently ongoing among patients seen in primary-care clinics to obtain a more accurate view of the situation in the general population.

As for the limitations of the present study, it must be said that the Neuropen® test, which is based on the detection of tactile and/or pain sensitivity loss, is less sensitive in detecting small-fibre neuropathy, which requires a test of thermal sensitivity. Therefore, our estimation of DPN prevalence should probably be regarded as conservative. Another limitation of our study in terms of identification of risk factors is that each patient’s height was not recorded, yet body height appears to be an important correlate of peripheral sensory neuropathy which, in turn, may help healthcare providers to identify those individuals at greater risk of DPN [1,3,9].

Nevertheless, our estimation of DPN prevalence based on the Neuropen® test is within the range reported by other studies. In fact, despite the wide variability due to methodological differences, a number of studies have nonetheless consistently reported overall DPN prevalence rates in the 20–30% range and up to 60% in patients with type 2 diabetes [1–3]. Our estimation of DPN—defined as the association of DPN with neuropathic pain as identified by the DN4 questionnaire—was 14%, with diabetes duration- and age-adjusted prevalence rates of 17.9% for type 2, and 5.8% for type 1, diabetic patients. This is consistent with previous studies carried out in referral centres that have reported DPN prevalence rates from 3.3% up to 30% [6–11]. Again, this wide range of prevalence may be explained by methodological differences (definition of DPN-P, diagnostic criteria, and sampling and data collection). In addition, most of these single-centre studies included relatively small numbers of patients and some did not even differentiate between pain and paraesthesia. Interestingly, our estimation is close to those reported by two community-based studies carried out in the UK, despite the use of different diagnostic methods. Daousi et al. reported a DPN prevalence rate of 16.2% (unspecified diabetes type) [6], while Davies et al. found a prevalence of 19% in a cohort of 269 patients with type 2 diabetes [11]. Taken altogether, these two studies and our data suggest that DPN can affect from one in six to one in five type 2 diabetic patients in community and diabetes-referral centres alike. These data strongly reinforce the importance of raising the awareness among both diabetologists and general practitioners of the clinical significance of these still underestimated neurological complications in diabetic patients [5].

The greater prevalences of DPN and DPN-P in type 2 diabetes may also be due to the fact that these patients were older than those with type 1 diabetes. However, such differences in age cannot entirely explain the striking disparities between these two groups of patients. Indeed, we found that several factors are associated with DPN and DPN-P, although interpretation of any correlation data must always be made with caution, as the mere coexistence of factors does not necessarily mean causality. Also, our multivariate analyses suggest that female gender, age, type 2 diabetes, diabetes duration and low HDL cholesterol are independent risk factors of DPN. In contrast, smoking, obesity, high blood pressure, high total cholesterol and high triglyceride levels along with other complications were not associated with DPN. As for DPN-P, our data suggest that age, diabetes duration, obesity, low HDL cholesterol, high triglyceride levels and nephropathy might represent independent risk factors.

Thus, DPN-P appears to be more prevalent when the metabolic syndrome-associated parameters are present. Indeed, it has already been reported elsewhere [13] that reduced HDL cholesterol levels combined with raised triglyceride levels—after adjusting for age, duration of diabetes and metabolic control—are good blood markers of changes occurring in the diabetic nervous system. In another prospective study, it was also noted that the presence of cardiovascular disease at baseline was associated with twice the risk of neuropathy and that alterations in the vasa nervorum might represent a crucial step in the development of neuropathy [14]. Recent work by the Kora Study Group demonstrated that DPN in prediabetes and diabetes is associated with abdominal obesity and macroangiopathy [15]. In line with these hypotheses, it is plausible that insulin resistance might promote the production of reactive oxygen species, thereby aggravating endothelial dysfunction and, in turn, neuro-ischaemia and neural damage [13,14].

Another goal of the present study was to evaluate the impact of DPN and DPN-P on QoL. To achieve this, we used the SF-12 questionnaire, a generic measure of health status proven to be reliable and valid when assessing physical and mental QoL in diabetic patients [20]. We found that DPN on its own had no effect on the physical or mental components of QoL. This might be due to the fact that the diagnosis of DPN in our study was based on ‘negative’ symptoms (such as sensory deficits) whereas the observed impact on QoL in other studies depended mostly on the presence of ‘positive’ symptoms (such as paraesthesia/dysaesthesia). Accordingly, our finding that DPN-P independently affects physical and mental QoL is consistent with those of previous studies [1–3,21].

Finally, our survey indicated that less than one-third (28%) of DPN-P patients were taking any recommended treatment for neuropathic pain (such as antiepileptics and/or antidepressants). This may explain the high mean pain intensity among our DPN-P patients and underscores these patients’ unmet needs in terms of neuropathic pain management—even in diabetes centres.

In conclusion, the present survey indicates that a significant proportion of diabetic patients (mainly type 2) suffer from DPN and DPN-P. The study also shows that the diagnosis can be easily made using inexpensive tools that do not require special expertise or experience to apply properly. Both conditions are often present together with other diabetes-related complications and metabolic syndrome-associated parameters. For this reason, it is essential both to raise awareness of DPN-P, as it deeply affects the patient’s QoL, and to encourage healthcare providers to better identify patients with DPN/DPN-P to improve their management.
Conflicts of Interests

None.

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